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ANNUAL RAINFALL VARIABILITY MAPS OF THE UNITED STATES

By EARL E. LACKEY

[University of Nebraska, Lincoln, Nebr., November 1938]

The series of rainfall maps herewith described involve the weather records of 2,077 stations in the United States. Only a few records were used that were not up to date, and none which included fewer than 20 consecutive years. A small number of records ran to more than 100 years.

In some rugged areas where stations were scarce and where a real distribution of rainfall was very uneven, a few stations with broken records or records shorter than 20 years were used.

In comparatively level areas the placing of isohyets was an easy task, but in areas of great relief a resort to inference and interpolation was imperative.

The five maps were constructed on the basis of quartile deviations. In order to do this the numerical record by years for each station was arranged in an ascending sequence and then the 0-, 25-, 50-, 75-, and 100-percentile points in the distribution were computed in inches.

In the distribution for any station the 100-percentile point indicates that the precipitation was equal to or more than the given amount 100 percent of the time. This value represents the least rainfall the station ever has received; that is, the minimum. When the minimum figures for each of the 2,077 stations were written on a map of the United States and isohyets drawn connecting points of equal amounts, a *map of the minimum annual rainfall of the United States* (figure 1) was obtained.

The 0-percentile values in the distribution represent maximum rainfall; that is, the precipitation was more than the designated amount 0 percent of the time. Stated in another way, this value represents the most rainfall the station has received during the time of record. When the maximum values for the 2,077 stations were placed on a map and the isohyets drawn, a *map of the maximum annual rainfall of the United States* (figure 5) was obtained.

In a similar manner, the 3d quartile (75 percent), median (2d quartile, 50 percent), and 1st quartile (25 percent) values in each of the 2,077 distributions were represented on maps of the United States; these are reproduced here as figures 2, 3, and 4, respectively.

When the five maps of annual rainfall variability are consulted, it is found that Baltimore has always received 21.6 inches or more (minimum);[1] that 75 percent (¾) of the time the precipitation was equal to or more than 34.4 inches; 50 percent (½) of the time, equal to or more than 40.6 inches; 25 percent (¼) of the time, equal to or more than 46.7 inches; and 0 percent of the time, more than 62.4 inches (maximum).

[1] The figures given here were taken from the computed distribution. However, readings from the maps should not depart far from these values.

THERMAL ASPECTS OF THE HIGH-LEVEL ANTICYCLONE

By THOMAS R. REED

[Weather Bureau Office, San Francisco, Calif., September 1938]

The warm-season phenomenon of an anticyclone in the upper air over the North American continent was pointed out a number of years ago by the writer [1] and he assumed at the time that it was thermally induced.[2] High temperatures at the surface were believed to be the principal cause, the inference being that when the lower atmospheric strata became warmed, due to the high surface temperatures prevailing over the western highlands in midsummer, the ensuing expansion produced a convexity in the higher isobarometric surfaces, which in turn set up an anticyclonic flow of winds around the high level "dome" thus created. The clockwise flow was revealed by synoptic studies of resultant winds at levels of 3,000 m. and higher, the circulation of which was found to conform with a fair degree of consistency to an anticyclonic pattern, centered in a majority of cases over the southern Rocky Mountains.

But while the statistical existence of the high-level cell seemed well supported by theory and observation, there was, initially, no direct evidence of its thermal structure. Subsequently, however, such evidence has become available. The data from airplane soundings which have accumulated in recent years have supplied it, and the purpose of the present paper is to set forth some of this information and show its relation to the phenomenon in question.

First, in support of the assertion that the high-level anticyclone is essentially a thermal phenomenon, let us examine the pattern of mean free-air isotherms in the midsummer months. (Figures 1 and 2). Free-air temperatures for July and August alone are considered, because the high-level "cell" is fully established only in those months, although it may be, and frequently is, in evidence in other months when surface temperatures are abnormally high and the prevailing westerlies relatively

[1] Thomas R. Reed, The North American High Level Anticyclone, MONTHLY WEATHER REVIEW, Nov. 1933, vol. 61, 321.

[2] Recently in an admirable contribution to the subject, Rossby has sought to account for the existence of this and similar anticyclones as dynamically, rather than thermally, induced eddies; and Namias has illustrated the application of the theory by an exegesis of isentropic movements associated with examples of the current systems involve. No doubt both factors play a part, but in the anticyclone under discussion the thermal factor seems to the writer paramount. Unfortunately this aspect is not yet susceptible of adequate isentropic treatment for two reasons: (1) the fewness of upper air sounding stations west of the 100th meridian and (2) the altitude of the available soundings, their height not being sufficiently great to permit the construction of isentropic charts at effective levels in the free air. For discussion of the dynamical theory see Rossby, Namias, and Simmers: Fluid Mechanics Applied to the Study of Atmospheric Circulations, Papers in Physical Oceanography and Meteorology, Vol. VII, No. 1, published by Massachusetts Institute of Technology, Cambridge, Mass., 1938.

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weak. Note that the mean free-air isotherms instead of traversing the country from west to east as in other months, form a series of roughly concentric contours over the western half of the United States, with the central isotherm of highest temperature embracing Colorado and parts of the adjoining states. The pattern is approximately the same for isotherms at 3,000, 4,000, and 5,000 meters above sea level. The highest mean temperature at the 3,000- and 4,000-meter levels is found over Cheyenne, Wyo.; and at the 5,000-meter level over San Diego. Presumably, if more aerographic data were available the

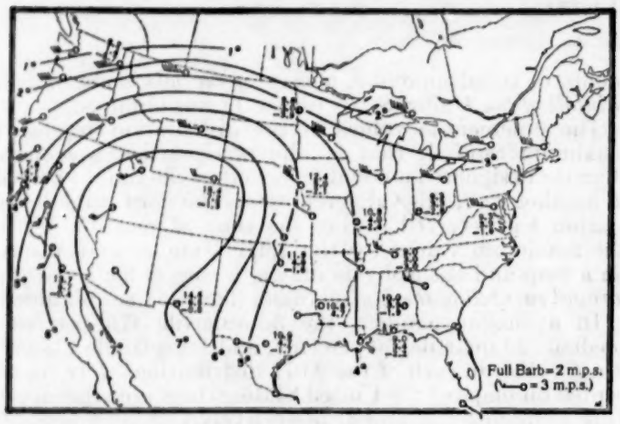


FIGURE 1.—Normal temperatures (°C.), and resultant winds in July at 4,000 m. Numbers reading from top to bottom, indicate normal temperatures at 3, 4, and 5 km., respectively.

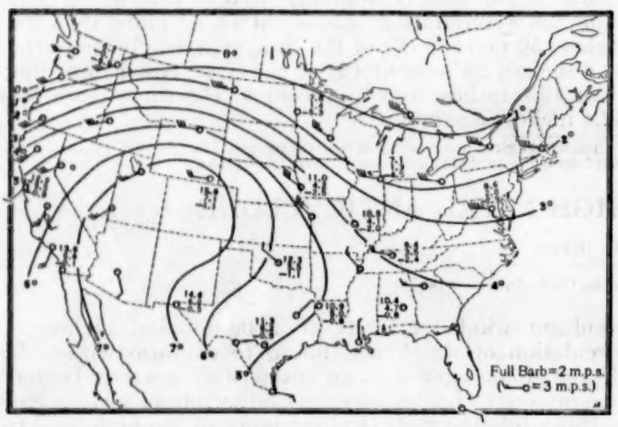


FIGURE 2.—Normal temperatures (°C.), and resultant winds in August at 4,000 m. Numbers, reading from top to bottom, indicate the normal temperatures at 3, 4, and 5 km., respectively.

maximum would be found somewhere within the triangle formed by Cheyenne, San Diego, and El Paso, as this area embraces not only a region of very high temperatures in midsummer but also a region in which the altitude of the surface of insolation is high. The upward bulging of the surfaces of isobarometric pressure associated with these free-air temperatures necessarily results in an effective dome of relatively high pressure at high levels over the region specified, and consequently in an anticyclonic circulation around the center of maximum pressure. Examination of free air resultant winds for the 3,000-, 4,000-, and 5,000-meter levels confirms this assumption and shows them to be in agreement with the thermal gradient, the wind arrows being approximately tangent to the isotherms. Thus the winds aloft are southeast to south over the south Pacific slope, south to southwest over the north Pacific slope, westerly over the northern Rocky Mountain region, northwest over the Missouri Valley, and north to east over the west Gulf States.

The fact of high mean temperatures in the free air over the western highlands in midsummer is not the only feature of note. The fact of high specific humidity is of equal interest. The mean values for this element are higher over the area under consideration than anywhere else over the continent at like levels, and approximate closely the specific humidities observed at similar levels over Coco Solo, in the Panama Canal Zone. As an example of these relationships the reader is referred to figure 3 which shows the mean specific humidities at the 3 and 4 kilometer levels in July 1937—a typical month. Note that the highest mean values are found over El Paso, Tex. (although very little higher than those over Salt Lake City), while the lowest values are found over San Francisco, Calif.

Thus, normally over Colorado and contiguous regions to the south and west there is in midsummer a condition not only of high temperature, but of high humidity as

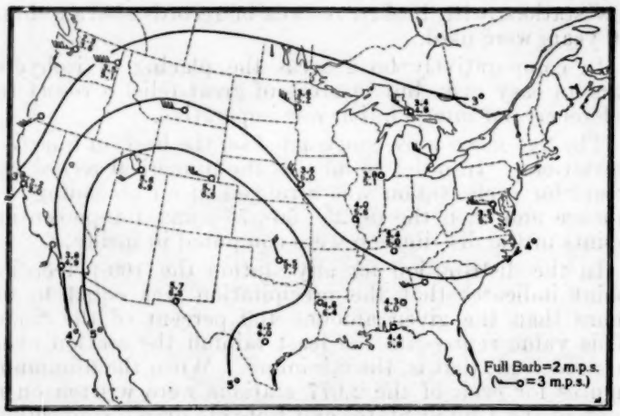


FIGURE 3.—July 1937. Specific humidity at 4,000 m (upper value), and 3,000 m. (lower value).

well. Moreover, as might be expected in an anticyclonic cell, there is likewise a condition of characteristically weak and variable winds. This, however, is true only of the central region within the high-level cell: the peripheral region, as has been already said, is one of anticyclonic gyration, and it is to this anticyclonic gyration and the various types of air embraced in it that the central region owes its importance as a climatic factor. In this respect the high-level cell may be considered a "center of action" in that it becomes an agency for initiating and maintaining a circulation that operates to bring both Tropical Atlantic and Tropical Pacific air masses into regions where they might not otherwise be found.

Thus it seems to effect a transport of T_A air from the Atlantic high-pressure cell and of T_P air from the Pacific high-pressure cell northward over the Pacific Slope, eastward over the northern Rocky Mountain States, and then southward over the Missouri and Mississippi Valleys. These air streams are easily identifiable if mean monthly values for equivalent potential temperature (Θ_E) are plotted for various levels from 3,000 meters up. (See figures 4 to 7) L. P. Harrison, in his summary of aerological observations in the August 1937 issue of the MONTHLY WEATHER REVIEW, made the following comment:

> The mean maximum free-air values of (specific humidities and equivalent potential temperatures) were found to be centralized over the southeastern portion of the Western Plateau region and contiguous areas to the east. Study of the patterns shown by the

monthly resultant winds, and the lines of constant value of these two elements constructed on charts for the various levels, discloses striking evidence of the probable existence, statistically at least, of a high-level anticyclone over the territory specified above. The three types of data referred to appear most consistent with this conclusion for levels from 3 to 5 kilometers above sea level, if it is assumed that the equivalent potential temperatures and the specific humidities undergo little change on the average in air masses transported along anticyclonic trajectories over the regions in question.

Especially significant are the mean values for equivalent potential temperature at the 3-, 4-, and 5-kilometer levels

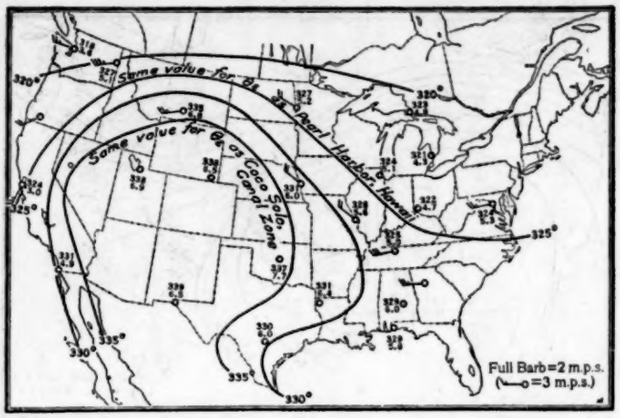


FIGURE 4.—July 1937. Equivalent potential temperature, specific humidity, and resultant winds at 3,000 m.

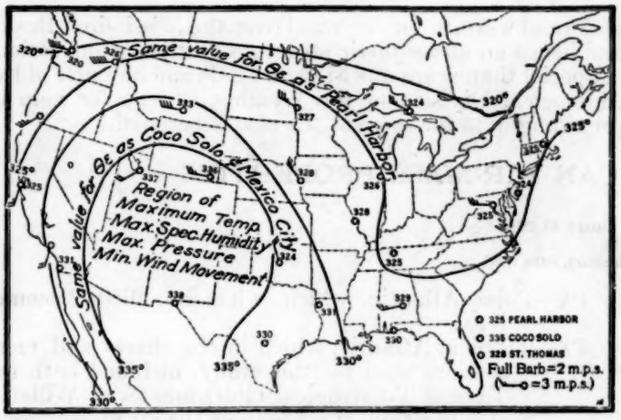

Same value for θE as Pearl Harbor
Same value for θE as Coco Solo & Mexico City
Region of Maximum Temp. Max. Spec. Humidity Max. Pressure Min. Wind Movement
O 325 PEARL HARBOR
O 335 COCO SOLO
O 328 ST. THOMAS
Full Barb=2 m.p.s.
(—o=3 m.p.s.)

FIGURE 5.—July 1937. Equivalent potential temperatures at 4,000 m., and resultant winds at same level.

within the high-level cell. They are higher within the cell than anywhere else at like levels either over the continent or in the tropics. In order to find as high values outside the anticyclonic cell it is necessary to look for them at lower levels. Thus in July 1937, the mean value 339° for θ_E found at the 4,000-meter level over Cheyenne, cannot be found anywhere above the 1,000-meter level at either Kelly Field, Tex., or Pensacola, Fla. The same relationships hold good in August, also. Moreover, the high values for θ_E within the cell are not restricted to the air over Cheyenne, but are found over Salt Lake City and El Paso, likewise.

This fact lends credence to the view that the high thermal energy content of the high-level cell has its source in strata of lower origin, being associated with air fed into the region of the cell below and lifted to the level of the cell by convection. Such an inference would account (partially, at least) for the higher values of θ_E within the cell than are to be found at like levels beyond its periphery. It also accommodates itself to the fact that like values for θ_E are found at comparatively low levels on the coast of the Gulf of Mexico. It is, furthermore, a fact of importance to consider in connection with the phenomenon of thunderstorms activity in the region normally occupied by the high-level cell, viz, the southern Rocky Mountains. Reference to Alexander's thunderstorm charts [3] shows this to be the region of greatest thunderstorm frequency in our country in midsummer outside of the east Gulf States.

In conclusion it may be worth while to point out the apparent relation that exists between surface temperature abnormalities and the position of the high-level cell. The latter is usually found over or to the south of the region of pronounced plus departures from normal temperature at the surface. Figures 8 and 9 illustrative of these obser-

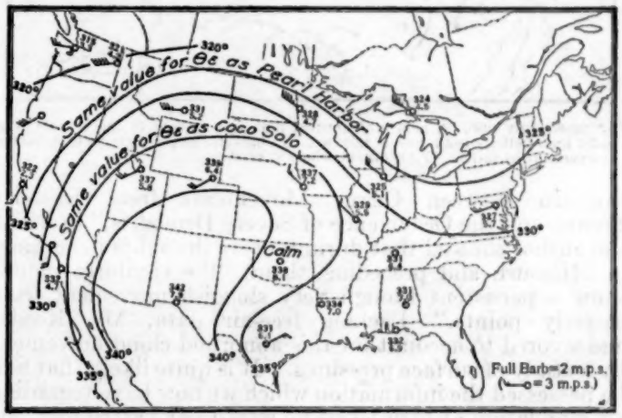


FIGURE 6.—August 1937. Equivalent potential temperatures, specific humidity, and resultant winds at 3,000 m.

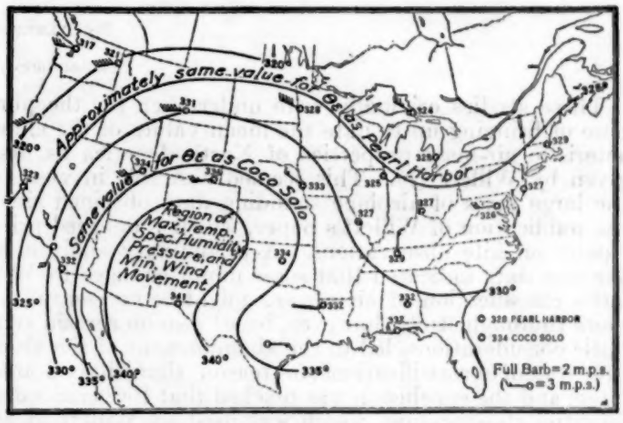

Approximately same value for θE as Pearl Harbor
Same value for θE as Coco Solo
Region of Max. Temp., Spec. Humidity, Pressure, and Min. Wind Movement
O 328 PEARL HARBOR
O 334 COCO SOLO
Full Barb=2 m.p.s.
(—o=3 m.p.s.)

FIGURE 7.—August 1937. Equivalent potential temperatures and resultant winds at 4,000 m.

vations show the mean isotherms and resultant winds at 4,000 meters in July and August 1936—a summer of memorable heat and drought in the Middle West. It will be noted that in July the region of greatest abnormality in surface temperatures was in the Dakotas, and the center of the high-level cell was just south of it. On the other hand, in August the region of largest temperature de-

[3] W. H. Alexander, "The Distribution of Thunderstorms in the United States," MONTHLY WEATHER REVIEW, Vol. 63, May 1935, p. 157-158.

parture was in Kansas, and the high-level cell was almost directly overhead.

Maj. E. H. Bowie has drawn my attention to an article by George Reeder which appeared in the MONTHLY WEATHER REVIEW of October 1919, entitled "The Relationship between Cirrus Movements from Easterly Points, and the Occurrence of Severe Droughts," in which the author showed that during severe droughts in summer in Missouri, and preceding them, "the cirriform clouds show a persistent though very sluggish movement from easterly points." Lacking free-air data, Mr. Reeder endeavored to account for this abnormal cloud movement by a study of surface pressures. It is quite likely that had he possessed the information which we now have regarding air circulation at high levels he would have attributed the phenomenon to other causes, for the easterly winds over Missouri could occur only when the high-level anticycline was far north and east of its normal position. Figures 8 and 9, just considered, may be taken as an example of an air structure probably approximating situations of the kind he described. It will be noted that in each case there was a northwest resultant wind over the upper Mississippi Valley, countered further south by a southeast resultant wind over Oklahoma. Note, too, the close agreement between resultant winds and isotherms, and how the high-level circulation has apparently maintained an air mass of abnormal warmth far eastward over the Mississippi Basin, and hence an atmospheric structure hostile to convection.

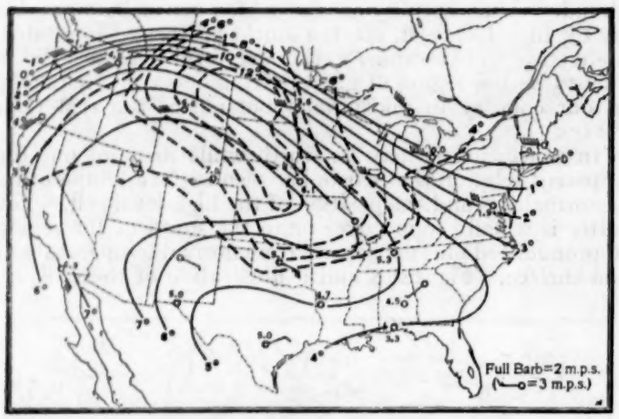


FIGURE 8.—July 1936. A month of unusual heat and drought in the Middle West Solid lines indicate isotherms at 4,000 m., °C.; broken lines, departures from normal temperature at surface, °F.; resultant winds at 4,000 m.

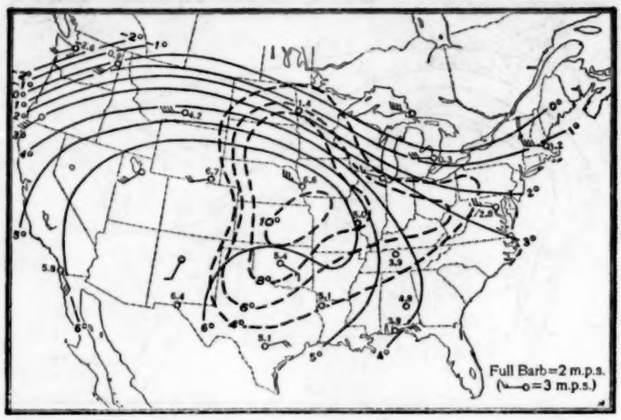


FIGURE 9.—August 1936. A month of unusual heat and drought east of the Rocky Mountains. Solid lines indicate isotherms °C. at 4,000 m.; broken lines, departures from normal temperature at surface °F; resultant winds at 4,000 m.

Special thanks are due Messrs. Little and Samuels of the Aerological Division of the Weather Bureau for help in providing data for some of the charts herewith.

FURTHER STUDIES OF AMERICAN AIR-MASS PROPERTIES

By ALBERT K. SHOWALTER

[Weather Bureau, Washington, June 1939]

These studies originally were undertaken for the purpose of bringing up to date the mean values of the characteristic air-mass properties of North America as first given by Willett (*1*). This seemed desirable in view of the large mass of airplane sounding data obtained since the publication of Willett's paper, which was based principally on kite observations. A preliminary analysis of the new data indicated that some minor changes in Willett's classification of air masses might be necessary. A more thorough study, however, based also on certain synoptic considerations, led to the abandonment of the absolute system of classifications, for reason that will be stated later; and the conclusion was reached that Bergeron's differential classification, which was used by Willett as an alternative system, forms a better basis for air-mass definitions.

The relation between the two classifications can be seen by listing and comparing them as follows:

Absolute classification (adapted from Willett)

Pc—Polar continental air which, after becoming modified, is called Npc (transitional polar continental).

Pp—Polar Pacific, and the modified form Npp.

Pa—Polar Atlantic, which, when modified, becomes Npa.

Ta—Tropical Atlantic, which in the charts and cross sections used for this study, included both the Ta and Tg (tropical Gulf) masses of Willett's classification, since both of the air masses come out of the subtropical anticyclone cell of the Atlantic.

Tp—Tropical Pacific.

Tm—Tropical maritime, a designation used when it is impossible to determine whether the air mass is of Atlantic or Pacific origin or when the two are mixed.

S—Superior, which includes all air masses which appear warm and very dry because, principally, of subsidence and divergence. S includes the type of air mass labeled Tc (tropical continental) in Willett's original publication and Ts (tropical superior) in later treatises by the same author (*2*).

Np—Modified polar, which is air definitely of polar origin but of doubtful continental or maritime origin, or a mixture of continental and maritime polar air. This type of air mass, which was not definitely classified by Willett, forms the predominant polar air mass of summer.

NPM—Modified moist polar; air which has become very moist (high relative humidity, moderately high temperature) by any of several possible means—by a long history over water, by precipitation through it, by evaporation into it from the surface, by mixing with TM air, or perhaps in some cases by cooling, either radiational or dynamic. This classification is not very desirable from a geographical standpoint, but for practical purposes it was used at first in the study. It included the terms NP *becoming* TM; NPPM, NPP *becoming* TP; NPC *becoming* NPA, NPA, NP+TM; and similar terms employed on synoptic charts and cross sections. The NPM designation does not appear in Willett's classification.

Differential classification (adapted from Bergeron) (3)

This classification implies the existence of two fronts separating three air masses—the Arctic front between Arctic and polar air, and the polar front separating polar from tropical air; the intertropic front does not enter into the scheme of things as far as the United States is concerned. The Arctic front, through southward migrations of the cold air, becomes a polar front, at which stage a new Arctic front usually is created, at least in winter. The minor cold and warm fronts, occluded fronts, etc., of middle latitudes are sections of the polar front; in fact under ordinary conditions the polar front is not a single, continuous front, although frequently it is approximately so.

cAW—Continental Arctic air, warmer than the surface over which it lies (stable in the low layers). This corresponds to the pure PC air mass at its source.

cAK—Continental Arctic air, colder than the surface over which it is passing (steep lapse rate in the lower layers). This corresponds to pure PC air that is moving rapidly and undergoing convectional or mechanical convergence around (usually behind) an intense cyclone in high latitudes.

mAK—Maritime Arctic air, colder than the surface over which it is passing (steep lapse rate). This corresponds to a mixture of PC and PP air masses flowing together rapidly down the Alaskan Pacific coast toward the United States, producing a type of weather somewhat distinct from that produced by the usual PP.

cPW—Continental polar air, warmer than the surface over which it is passing (stable in the lower layers). Corresponds to stable NPC, PP, or NPP modified over the continent, the latter type sometimes classified as NPPC [see Byers (4)].

cPK—Continental polar air, colder than the surface over which it is passing (steep lapse rate). Corresponds to NPC, NPPC, and NP that have been heated from below, especially in summer.

mPW—Maritime polar air, warmer than the surface over which it is passing (stable in the lower layers). Corresponds to a return current of NPP over the ocean (NPPM according to Byers) or PP becoming NPP by rapid cooling in the valleys and basins of the Far West in winter. Sometimes also corresponds to a return current of stable NPA, or NPM.

mPK—Maritime polar air, colder than the surface over which it is passing (steep lapse rate). Corresponds to fresh PP and some forms of NPP, PA, and NPM.

mTW—Maritime tropical air, warmer than the surface over which it is passing (stable in the lower layers). Corresponds to certain types of TA, TP, and NPM.

mTK—Maritime tropical air, colder than the surface over which it lies or is passing (steep lapse rate). Corresponds to TA, perhaps occasionally also TP.

Superior air (S) is not of surface origin and is the same in both classifications. Continental tropical air does not appear in North America.

The outstanding characteristics of the various air masses may be outlined as follows:

WINTER SEASON

Continental Arctic Air

As shown by Willet (1) and Wexler (5) cA air is probably formerly maritime polar air (mPK) which is cooled by surface radiation forming cAw. A study of this air mass by Wexler has shown that there is a very sharp inversion near the surface, and above, a lapse rate approaching the isothermal. The rapid increase with height of potential temperature as shown for cAw air in figure 2 illustrates the exceptional stability of this air mass. Since the effect of surface cooling rarely extends above 3 km. above sea level, the uncooled air above would still be mP and very few observations of cA air are available above that level. Occasionally cA air is mechanically lifted to 4 km. at Cheyenne and in such a case it will be cooled adiabatically and a temperature very low for that height will result. Unstable Arctic air, cAK, sometimes occurs in the Hudson Bay and the Great Lakes regions but insufficient data are available to include cAK air in this study.

The modifying influences affecting cA air are principally the addition of heat and moisture at the surface and a tendency for subsidence aloft. A complete discussion of cA (PC) air and other air masses is contained in Willett's paper and it is the author's intention to avoid needless repetition of the important modifying influences. The change in designation from cAw to cPw has been more or less arbitrary but usually one or two days elapse before cAw air is considered cPw. A more definite criterion for the change in notation is the formation of a new Arctic front. Eventually the original polar air may become tropical air, so cPw merely marks the transitional stage.

The striking thing in the movement of cAw *becoming* cPw air into the southern United States is that the steepening of the lapse rate which would be expected from the addition of heat from below does not occur in the mean, except in the lowest few hundred meters. Apparently subsidence proceeds so rapidly at all levels above the shallow turbulent-convective layer that the great stability characteristic of cAw air near its source is still preserved and cAw→cPK is rare, except behind deepening cyclones. As the polar air feeds into low latitudes it spreads out to occupy several times its original area and thus the compensating subsidence shown by the various charts and tables is accounted for.

The properties of cPw air, as would be expected, are about midway between the properties of Arctic and Tropical air.

There seems to be considerable moisture added in the lower levels by surface evaporation but because of the extreme stability of cAw and cPw air it does not seem likely that the effects of surface addition of moisture extend to any appreciable elevation. Consider for example, the mean value of 2.2 g./kg. for specific humidity with a potential temperature of 288°A. at 2 km. at Oklahoma City in cPw air. (See fig. 2.) To establish an adiabatic lapse rate to carry such a quantity of moisture up to 2 km. by vertical convection, a potential temperature of 288° A. is required at the surface. Since a surface potential temperature of 288° A. is found only in air of very nearly tropical properties it is evident that the observed amount of moisture could not have been carried up to that elevation by simple vertical convection. The addition of moisture at higher levels in modified polar air is probably best explained by the theory of horizontal mixing along isentropic surfaces as discussed by Rossby (*6*).

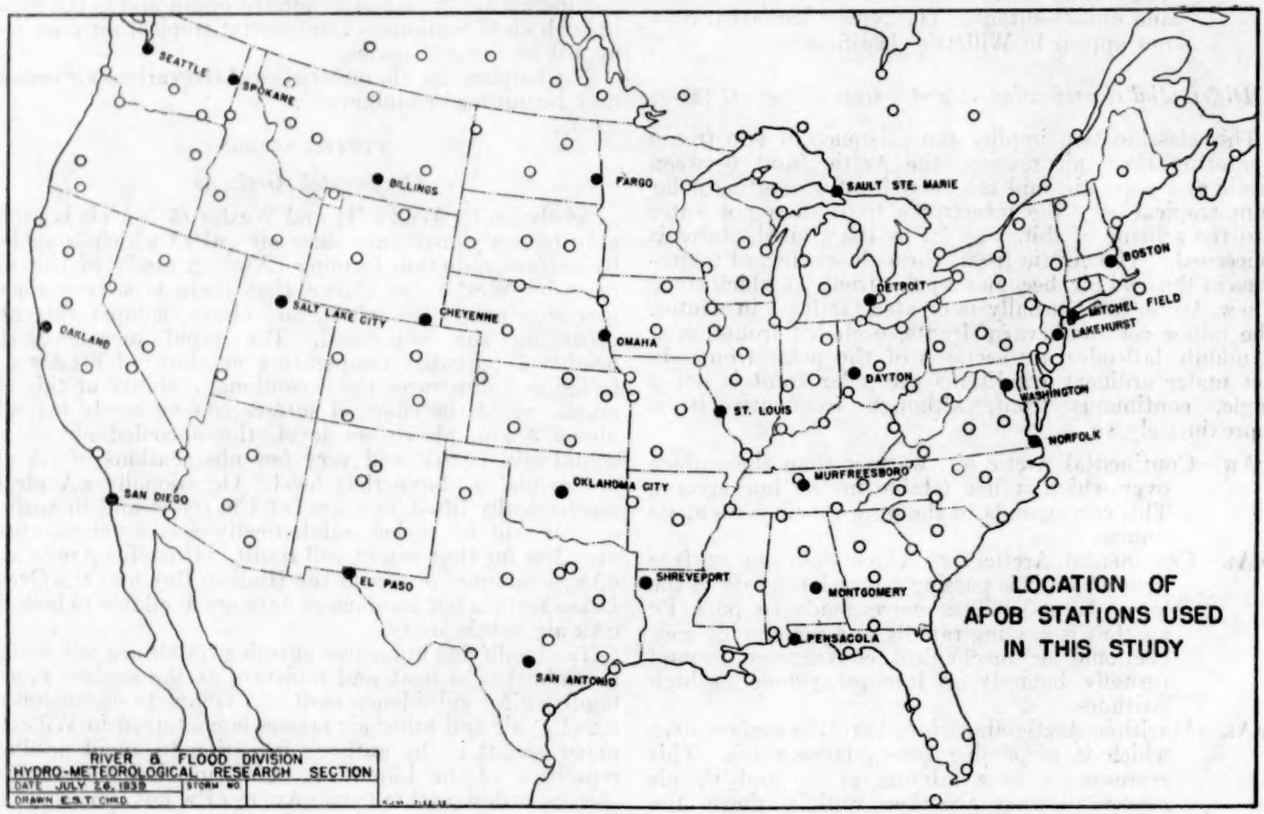


FIGURE 1.

Maritime Arctic air, MA

When an outbreak of polar air moves over only a very small part of the Pacific Ocean before reaching the United States it is usually designated as MAK. If its trajectory has been far to the south, it usually is sufficiently modified to be called MP. Since MA air must have properties closely resembling those of cA air before moving out over the ocean it is possible to estimate the minimum values of its various properties. Assuming a pressure of 1,000 mb. at the surface, which is a reasonable value for a winter MA current, a minimum temperature at the surface of 0° C. and 75 percent of saturation as would be expected in this air mass, and employing a pseudo-adiabatic diagram, it is found that the assumed conditions result in a specific humidity of 2.8 g./kg., and an equivalent-potential temperature of 280° A. If vertical convection with constant equivalent-potential temperature obtained to 5 km. above sea level in such an air mass the temperature at 5 km. would be about −43° C. The lowest temperature observed at 5 km. in MAK air was −43.4° C. at Spokane on February 7, 1936. It must be borne in mind that the above are minimum values of the properties of MAK air and most of the outbreaks do not result in such low values. In fact the mean values here summarized are much too high for typical MAK air. The means were obtained from sampling of air originally classified as PP. They represent observations of MAK, MAK→MPK or MPW, and MPK→MPW. Strictly speaking, for air masses entering the United States, the notation MAK should be reserved for Arctic air masses which move directly southward along the North Pacific coast and have only a short trajectory over the ocean. The notations MPK and MPW are adequate to differentiate between maritime polar outbreaks having longer trajectories. (See fig. 7.) The unusual instability of MAK air, some flights indicating that vertical convection has obtained to at least 6 km., has two important effects on its interaction with other air masses in the central and eastern part of the United States. First, since often it is colder aloft than the surrounding air masses, sinking from these levels, or subsidence, occurs in MA and MP air. Second, and inversely, this same instability in MA air is apt to cause an increasing tendency for vertical divergence and increasing instability in air masses moving into a region occupied or recently occupied by MA

air. In other words, the mA gains in stability while the surrounding masses lose.

During the winter months mA air near the surface is usually warmer than the continent, and shortly after passing the coast line it becomes a warm type air mass according to the Bergeron classification. Over snow covered areas mAk air very rapidly assumes continental characteristics; thus we find the modified form of mA air sometimes colder near the surface than the original.

Because of the mountain ranges in the western part of the United States and the presence at the surface of cold continental air, most of the Pacific air masses in winter move eastward over the continent without reaching the surface, except in certain unusually warm winters.

The effects of surface modification on polar Pacific air masses over the United States are but slight in the winter months except as the air masses approach the more southerly stations. The mean values for mP air cannot be

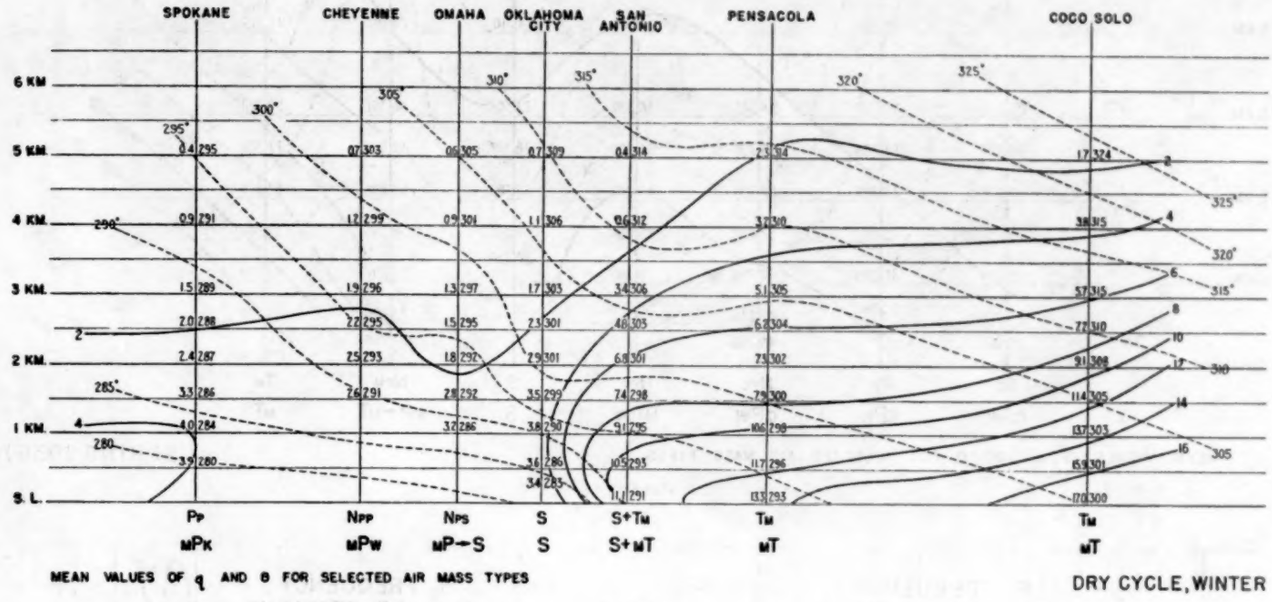


FIGURE 2.

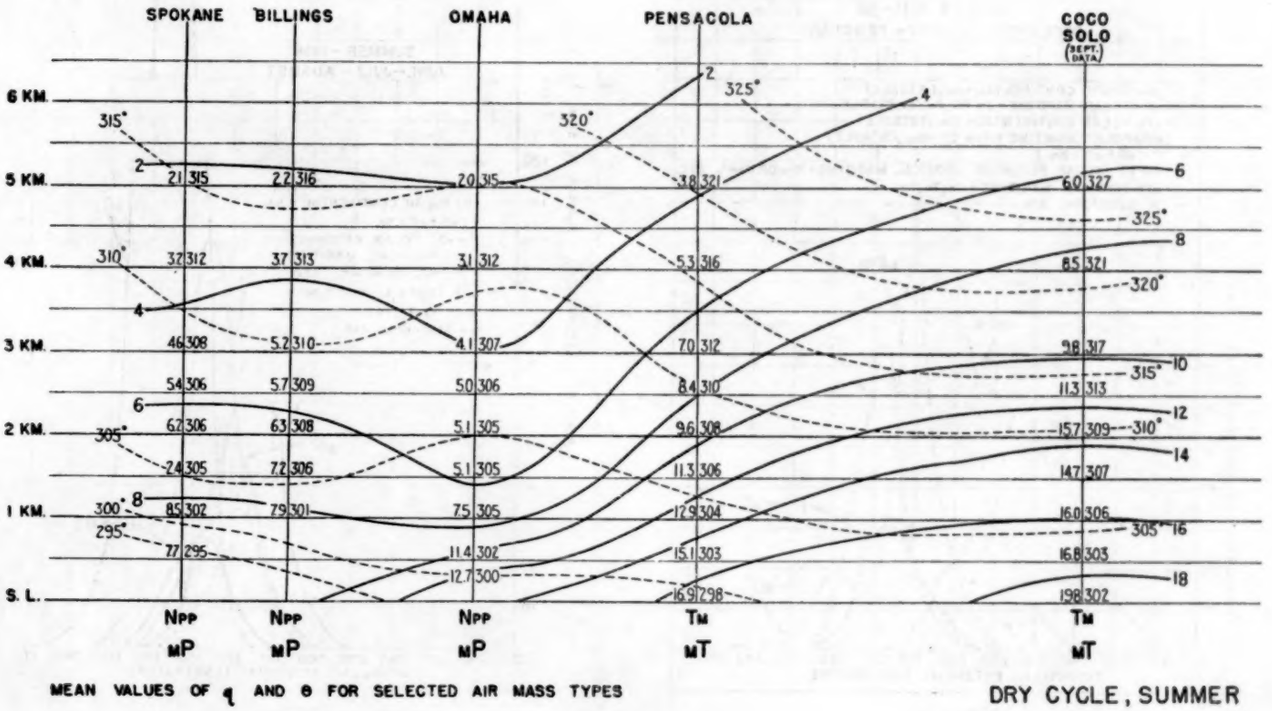


FIGURE 3.

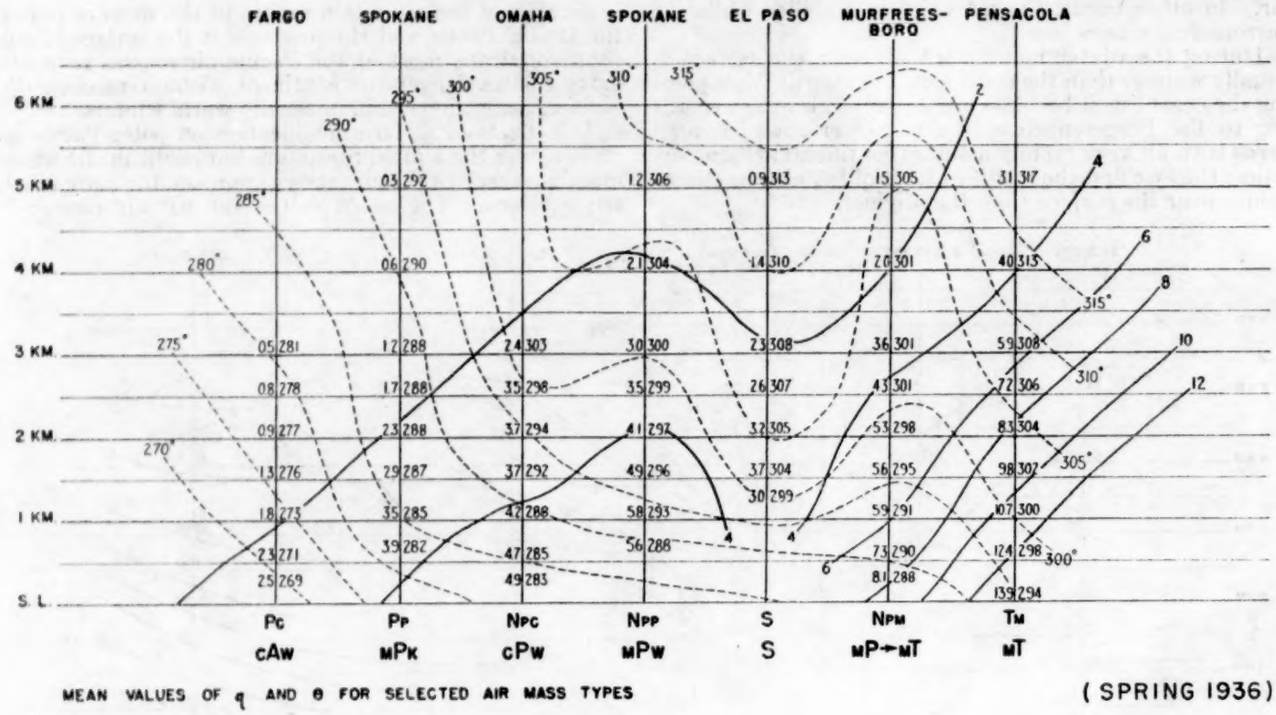


FIGURE 4.

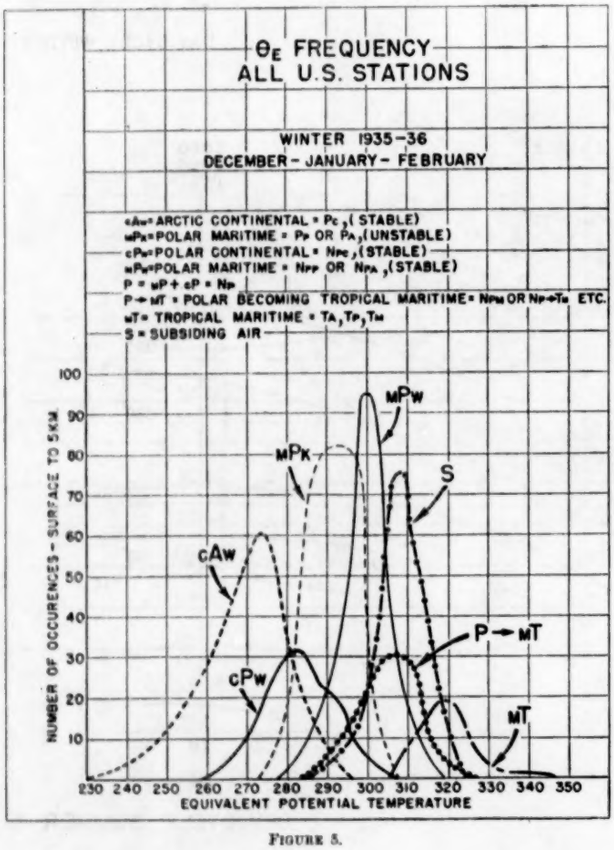

θE FREQUENCY
ALL U.S. STATIONS
WINTER 1935-36
DECEMBER-JANUARY-FEBRUARY
cAw=ARCTIC CONTINENTAL = Pc, (STABLE)
mPK=POLAR MARITIME = PP OR PA, (UNSTABLE)
cPw=POLAR CONTINENTAL = NPC, (STABLE)
mPw=POLAR MARITIME = NPP OR NPA, (STABLE)
P = mP + cP = NP
P→mT = POLAR BECOMING TROPICAL MARITIME = NPM OR NP→TM ETC.
mT = TROPICAL MARITIME = TA, TP, TM
S = SUBSIDING AIR
NUMBER OF OCCURENCES - SURFACE TO 5KM.
EQUIVALENT POTENTIAL TEMPERATURE

FIGURE 5.

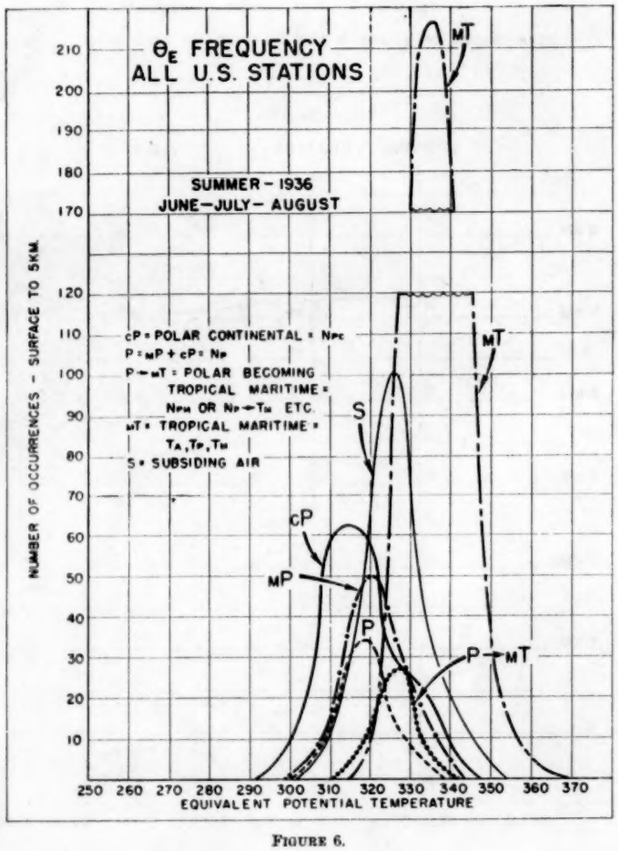

θE FREQUENCY
ALL U.S. STATIONS
SUMMER - 1936
JUNE-JULY-AUGUST
cP = POLAR CONTINENTAL = NPC
P = mP + cP = NP
P→mT = POLAR BECOMING TROPICAL MARITIME = NPM OR NP→TM ETC.
mT = TROPICAL MARITIME = TA, TP, TM
S = SUBSIDING AIR
NUMBER OF OCCURENCES - SURFACE TO 5KM.
EQUIVALENT POTENTIAL TEMPERATURE

FIGURE 6.

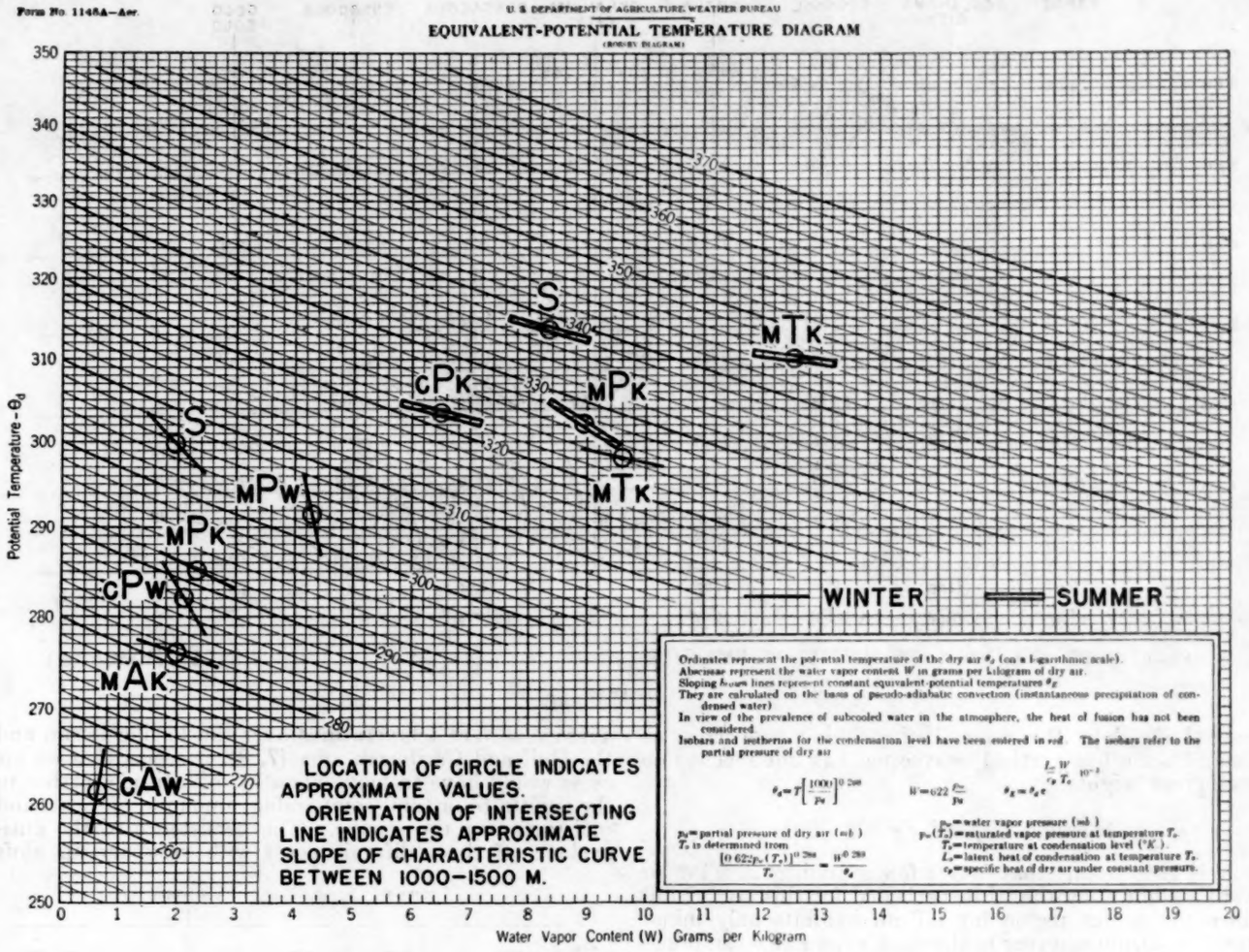

Form No. 1148A—Aer.
U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU
EQUIVALENT-POTENTIAL TEMPERATURE DIAGRAM
(ROSSBY DIAGRAM)
Potential Temperature - θ_d
Water Vapor Content (W) Grams per Kilogram
S
mPK
cPK
mTK
mPW
cPW
mAK
cAW
WINTER
SUMMER
LOCATION OF CIRCLE INDICATES APPROXIMATE VALUES.
ORIENTATION OF INTERSECTING LINE INDICATES APPROXIMATE SLOPE OF CHARACTERISTIC CURVE BETWEEN 1000–1500 M.
Ordinates represent the potential temperature of the dry air θ_d (on a logarithmic scale).
Abscissae represent the water vapor content W in grams per kilogram of dry air.
Sloping broken lines represent constant equivalent-potential temperatures θ_E
They are calculated on the basis of pseudo-adiabatic convection (instantaneous precipitation of condensed water)
In view of the prevalence of subcooled water in the atmosphere, the heat of fusion has not been considered.
Isobars and isotherms for the condensation level have been entered in red. The isobars refer to the partial pressure of dry air
$\theta_d = T\left[\frac{1000}{p_d}\right]^{0.288}$ $W = 622\frac{p_w}{p_d}$ $\theta_E = \theta_d e^{\frac{L_v W}{c_p T_c} 10^{-3}}$
p_d = partial pressure of dry air (mb)
T_c is determined from $\frac{(0.622 p_w (T_c))^{0.288}}{T_c} = \frac{1000^{0.288}}{\theta_d}$
p_w = water vapor pressure (mb)
$p_w(T_c)$ = saturated vapor pressure at temperature T_c.
T_c = temperature at condensation level (°K).
L_v = latent heat of condensation at temperature T_c.
c_p = specific heat of dry air under constant pressure.

FIGURE 7.

considered representative of the effects of continental modification; first, because the notation mP is also applied to air masses which have had a trajectory far to the south over the Pacific Ocean; second, because of the tendency for subsidence in Polar Pacific air, a large number of samples of the modified form of this air mass have been classified as S air in the course of this study; third, because a few samples of modified Pacific air which were rapidly assuming tropical maritime characteristics were summarized under a special group. It seems safe to say that some of the increase in moisture at higher levels cannot be explained by vertical transport and must be explained by isentropic mixing.

Samplings of maritime polar air from the Atlantic, and its modified forms are quite rare in the winter months because this type of air mass is usually off the New England coast, and when it does move inland its tendency for instability and saturation usually results in conditions too hazardous for flying. The few samplings available in this and other studies indicate that Polar Atlantic air in

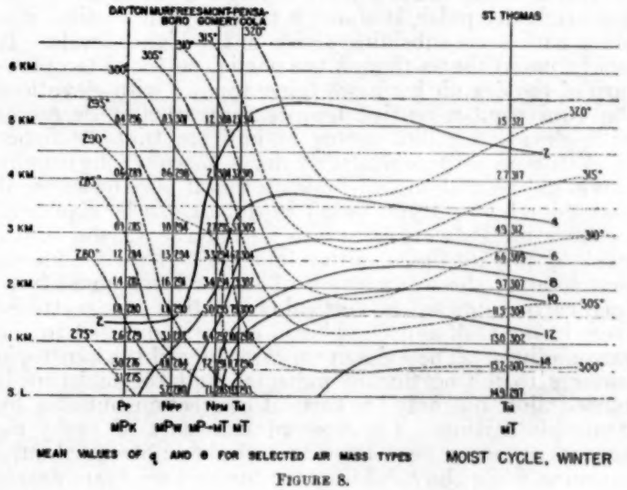


FIGURE 8.

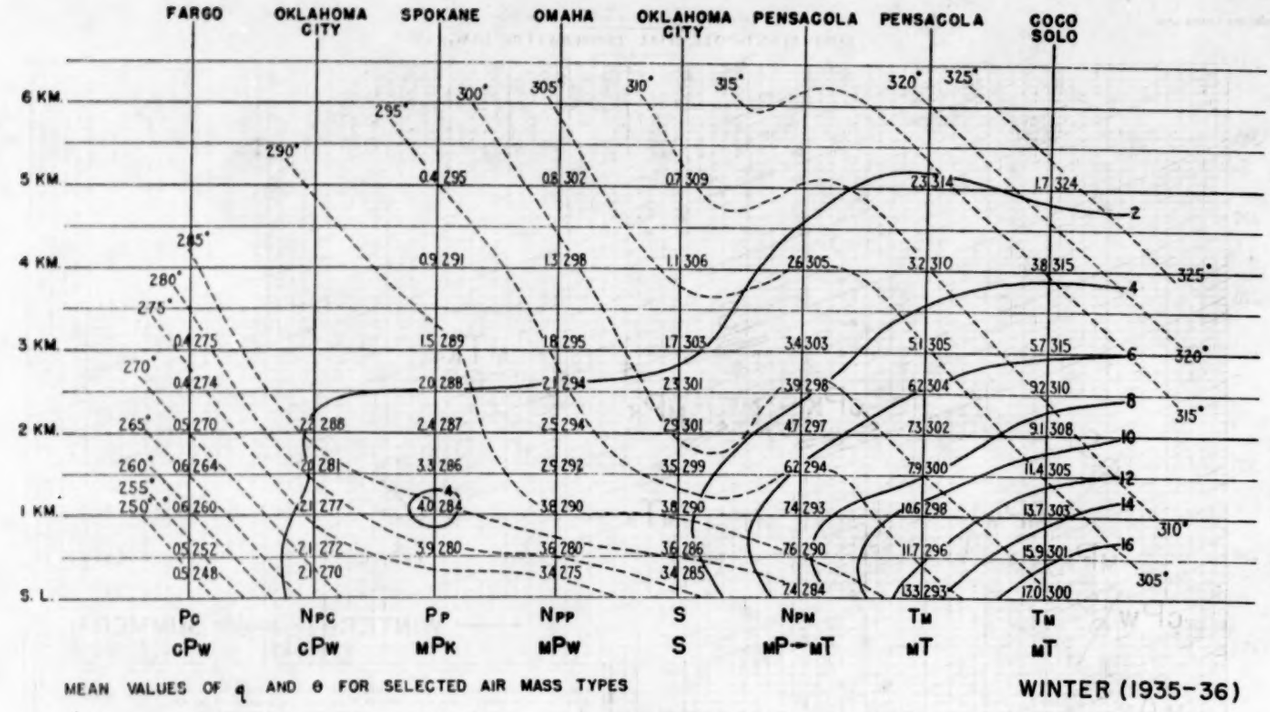


FIGURE 9.

general develops the same distinguishing properties as Polar Pacific but vertical convection has not reached to such great heights.

Maritime tropical air mT (Tm)

It is unfortunate that only a few soundings in mTw air were made during the winter selected for this study; but since the source region for mT air exhibits only minor variations from one year to the next, even a few samplings of mTw air can be considered representative of its general characteristics. Since mT air is formed out of air which was originally polar, it shows a tendency for vertical stability with some subsiding action in the higher levels. It will be noted that although the partial-potential temperature of the dry air increases fairly rapidly with elevation, the equivalent-potential temperature usually decreases with elevation. This seems to indicate that at higher levels this air mass is relatively dry. Since mT air usually moves inland with anticyclonic motion it may be assumed that the relative dryness aloft in mT air can be explained by horizontal divergence with subsidence in the upper levels of the subtropical anticyclonic cell. There is evidence that some of the water vapor at higher levels must have been carried upward by vertical convection over scattered areas in the Gulf and Caribbean, and was diffused to the surroundings. The evident upward slope of the isentropic surfaces to the northward indicates that the moisture is carried aloft not only by vertical convection but also by isentropic mixing. The upward transport of moist air appears to occur near the edges of the subtropical anticyclones, while the subsiding dry tongues originate nearer to the centers.

Due to the lack of adequate history for the trajectories of tropical maritime air entering the western part of the United States, it is difficult in most cases to identify positively Tp air masses as such. From a comparison of average surface temperatures over the Pacific Ocean and the Gulf and Caribbean area (**7, 8**), it seems that an air mass would have to move about 5° of latitude farther to the south to attain comparable amounts of heat and moisture over the Pacific. The persistence of the anticyclone off the California coast with very dry air aloft

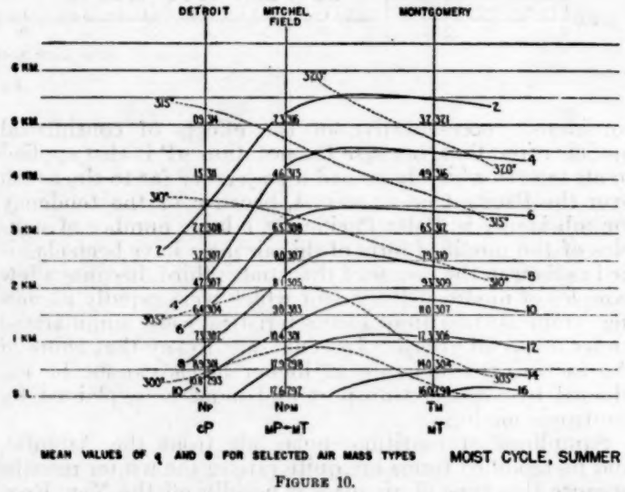


FIGURE 10.

seems to demand that in any northward movement, tropical Pacific air would be exposed to likelihood of both horizontal isentropic mixing and mechanical vertical mixing with much drier air. Not enough samplings of Tp air are available to show definitely that it possesses any characteristics distinct from tropical Atlantic air. The values obtained for Manila by Deppermann (**9**) seem to agree well with the values obtained for Coco Solo and St. Thomas in this study.

Superior or subsiding air S (Ts)

The notation Ts (tropical superior) was originally applied to air supposed to have been derived from the upper subsiding portions of the subtropical anticyclonic cells (**2**). However, of recent date the designation S has been applied to all warm air masses that show relative humidities below 40 percent, which is taken as an indication of subsidence and horizontal divergence. The study indicates that most of the dryness results from the subsidence of high level air from a polar source. Isentropic analyses have shown definitely that a number of dry tongues move out from polar regions. Consider for example the potential temperature surface of 302° A.; mP air shows an average specific humidity of 0.8 g./kg. for that surface, and mT air an average of 7.3 grams. The average value of 2.0 g./kg. given for S air at this surface indicates that the main source of the dryness in S air is probably the upper levels of the polar air, but that the average also includes a number of cases of air of tropical or subtropical origin as well as cases of isentropic mixing between air from tropical regions and subsiding air of a polar source. Further studies of the general circulation on the basis of isentropic charts may show that all dry air aloft, even in the tropics, comes from high latitudes.

Modified moist Polar air mPw (Npm)

All of the various types of modified polar air which were rapidly becoming warm and moist were grouped under the heading of Npm for purposes of this study. The mean values for these air masses show a tendency for decreasing stability and increasing moisture content. Although there is evidence that considerable heat and moisture are added by surface effects, there must be an addition of moisture aloft by isentropic mixing. The fact that a large number of Npm soundings show humidities at or near saturation makes it impossible to make quantitative estimates of the effects of addition of moisture at the surface. In other words, conditionally stable air under saturation conditions moves along equivalent-potential temperature surfaces, and prior to saturation the air moves along potential temperature surfaces (**10, 6**), and since the mean values represent a large number of saturated conditions it is impossible to differentiate between the effects of vertical convection and isentropic mixing in Npm air.

SUMMER SEASON

Continental polar air cA→cP (Pc→Npc)

As explained by Willett (**1**) surface conditions in the source region of cA air in the summer are considerably different from winter conditions. Both the mP and cP are originally Arctic air masses and have similar properties at their source, but undergo different influences on their journey to the United States. cA→cP air undergoes very rapid surface heating and slow addition of moisture. Since so few cases of cA air have been classified as such it is safe to say that during the summer months all outbreaks of cold continental air are sufficiently modified to be labeled cP by the time they reach the United States. Because most of the flights are taken before sunrise the mean values for cP air show great stability up to 2 km. As noted by Willett (*1*) there is a large diurnal range in the temperature in continental air during the summer months so that by midafternoon on clear days most of the stability in the lower 2 km. has been removed. The rate of increase of moisture aloft seems slightly in excess of that possible through vertical convection and it is necessary to believe that horizontal mixing plays an important role.

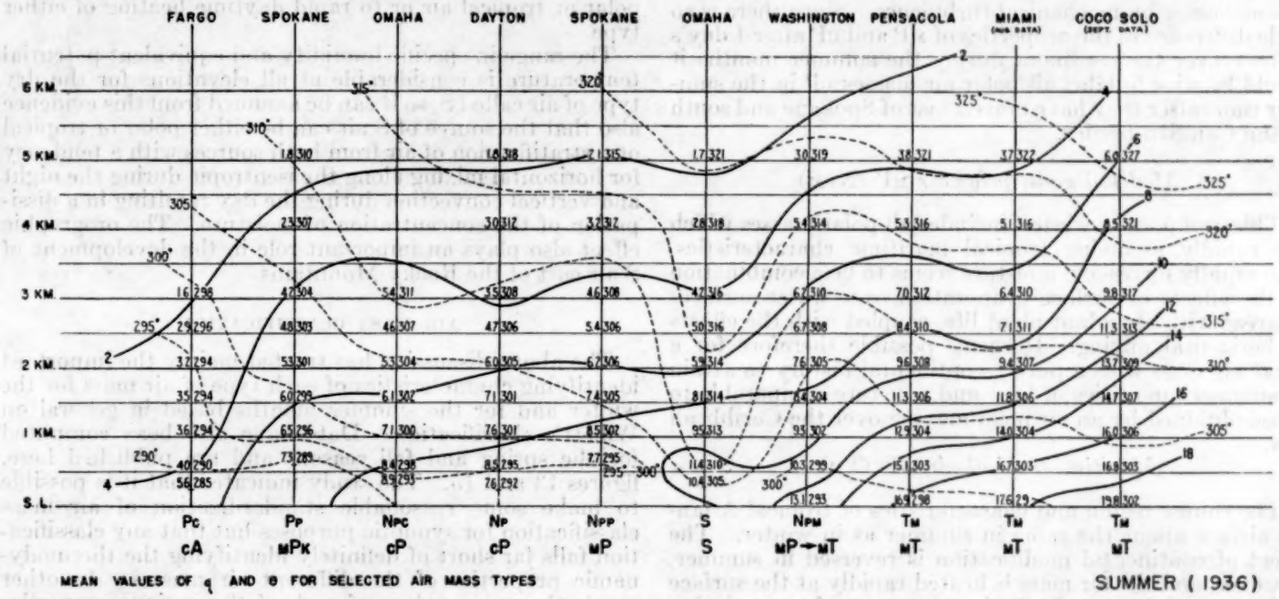


FIGURE 11.

Maritime polar air mA→mP (Pp→Npp)

The source of mA air is originally Arctic, but its trajectory over the Pacific Ocean leads to a fairly rapid increase in moisture. However, because of the cool waters of the Pacific and the small diurnal range in temperature over the water, the addition of heat is slower than it would be over the land. As soon as the maritime air mass moves inland it is heated very rapidly. Further, because of the usually long maritime trajectory, polar Pacific air masses

are quite warm as a rule by the time they reach Spokane or Billings, so it is usually advisable to use the notation mP during the summer months.

Although it is not so pronounced in the summer time, the tendency for subsidence in Pacific air masses moving across the Rockies has about the same general effect as it has during the winter months. There is a rather large diurnal temperature range in mP air over the land and apparently considerable moisture is added by vertical convection in the lower levels.

The effects of subsidence and outflow from the upper portions of mP air seem to have about the same prominence as the effects of horizontal mixing so the mean values for mP air do not give positive evidence of the increase of moisture aloft by isentropic mixing.

The notation cP or NP should be used in cases of doubtful history of the polar current, or in cases of overlapping layers of maritime and continental air having been thoroughly mixed by vertical convection during the day or in some cases by mechanical turbulence. Since there is so little difference in the properties of mP and cP after 1 day's history over the continent during the summer months it would be wise to label all polar air masses cP in the summer time, after they have moved east of Spokane and south of the Candian border.

Modified moist polar air mP (NPM)

This group, as in winter, includes all polar masses which are rapidly assuming tropical maritime characteristics. The rapidly increasing moisture seems to be a combination of the effects of surface evaporation over water surfaces or areas with abundant plant life, coupled with the effects of horizontal mixing. It seems possible therefore for a polar air mass with a purely continental history to attain in summer quantities of heat and moisture comparable to those obtained by an air mass moving over the Caribbean Sea.

Maritime tropical air mT (TM)

The source region and characteristics of tropical Atlantic air are about the same in summer as in winter. The effect of continental modification is reversed in summer, however, and the air mass is heated rapidly at the surface as it moves inland and mT air masses very frequently become unstable during the day. It appears that in general the potential temperatures are higher in mT air than in continental air masses and that therefore the air would move upward along the isentropic surfaces as it came over the land. Some of the cases studied indicate that at times a given isentropic surface may slope downward from the Gulf to the continent. This means that portions of the mT column may at times move downward in approaching the continent. It will be noted that mean potential-temperature surfaces are approximately horizontal between Miami and Pensacola.

Taking the vertical distance in meters between the 303°A. and the 311°A. surfaces as an inverse measure of stability, one finds the mT air to be more stable in the mean than mPK air but less stable than cPw air. This agrees with the statement made during the discussion of mP air wherein the author stated that mP air was likely to cause increasing instability in air masses moving into its territory. The author is of the opinion that it can be statistically proved that the greatest probability of rain occurs when mT air replaces mA or mP, or when mA or mP replace mT air. The latter sequence is more conducive to precipitation during the colder seasons.

Samplings of tropical Pacific air were not included for the summer season since such an air mass is extremely rare over the United States during that season and has no properties different from other maritime tropical air masses.

Superior or subsiding air (S)

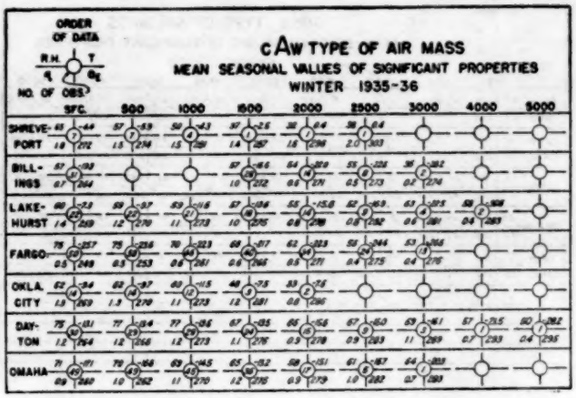
The assumption that the dryness of this air mass is due to subsidence is not necessarily correct in summer, because rapid surface heating of relatively dry air at that season may produce a deep column of air whose moisture content is far from the saturation values. When such an air mass is cooled during the night by surface radiation some slow sinking may occur in the layers near the surface and those layers which are not cooled by radiation will show low relative humidities by the time of the airplane observation the next day. Since S air is recognized only on the basis of relative humidities less than 40 percent, the source of this air can therefore be traced to subsiding polar or tropical air or to rapid daytime heating of either type.

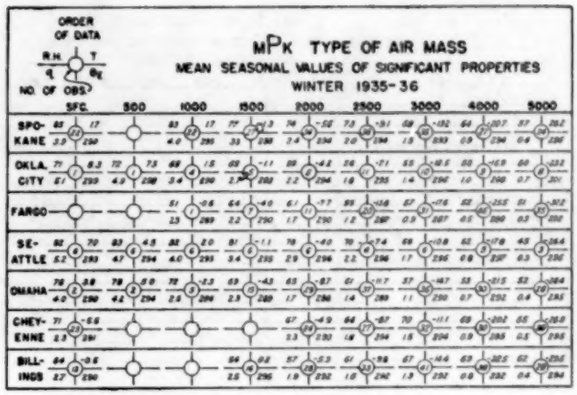
The range in specific humidity and equivalent potential temperature is considerable at all elevations for the dry type of air called S, so it can be assumed from this evidence also that the source of S air can be either polar or tropical or a stratification of air from both sources with a tendency for horizontal mixing along the isentropic during the night and vertical convection during the day resulting in a dissipation of the concentration of moisture. The orographic effect also plays an important role in the development of S air east of the Rocky Mountains.

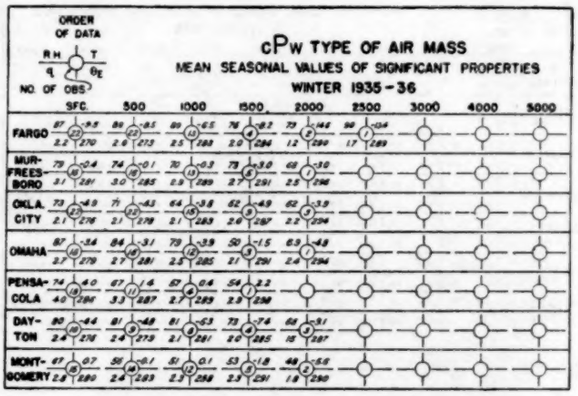
AIR MASS CLASSIFICATION

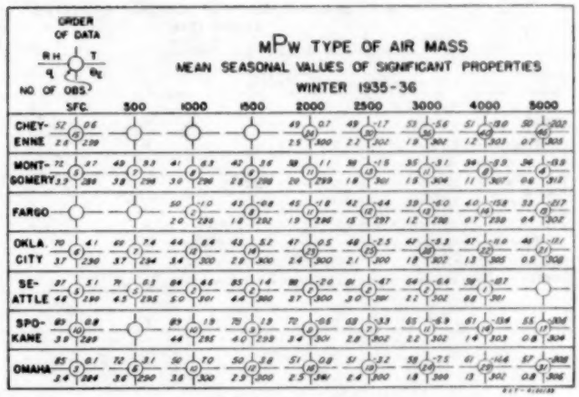
The above discussion has treated mainly the important identifying characteristics of each type of air mass for the winter and for the summer months based in general on Willett's classification. Data have also been computed for the spring and fall seasons and are published here, figures 13 and 15. The study indicates that it is possible to make some reasonable standardization of air mass classification for synoptic purposes but that any classification falls far short of definitely identifying the thermodynamic properties of the different air masses. In other words the mean values of each of the various properties (see figs. 12 to 15) show definite groupings for the different air masses, and the individual values show definite limits for the properties of fresh tropical and fresh polar outbreaks. However, the modifying influences affecting air masses and the almost arbitrary method of classifying air masses, especially in the summer months, result in a very wide range of equivalent-potential temperatures as indicated on the frequency distribution charts (figs. 5 and 6). It can be seen from a study of these charts that the classification is relative for any one day, and no definite limits of equivalent-potential temperature have been in use. This seems regrettable for statistical purposes but in practical synoptic work it can hardly be avoided.

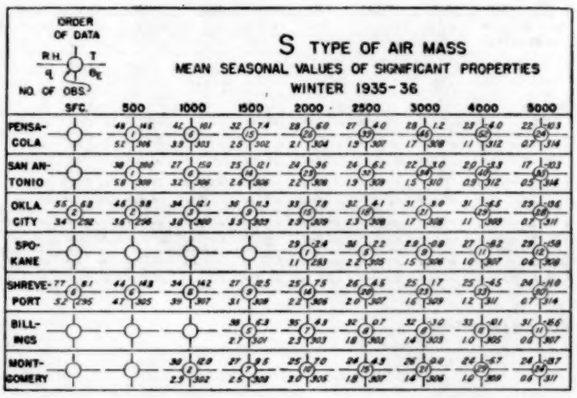
It is usually the practice to label the air masses differently on either side of a front, and since polar air is sometimes modified very rapidly, it happens that modified polar air behind a cold front on one weather map may have a higher equivalent-potential temperature than a modified tropical current behind a warm front on a map a week later. Since all tropical air is polar air modified by surface effects, any classification of air masses must be only a compromise as to number of types. The author is of the opinion that no purpose is served by increasing the











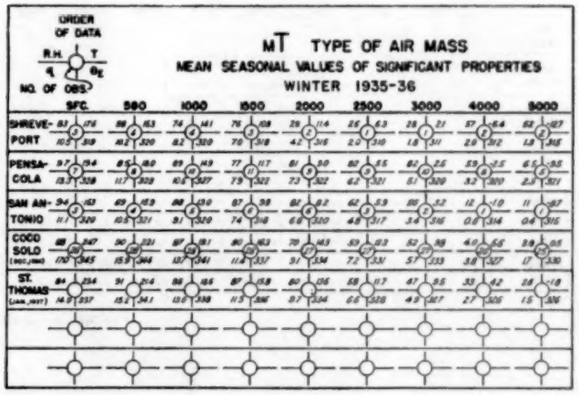
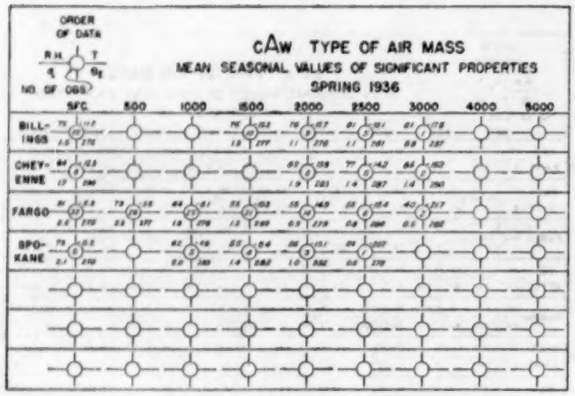
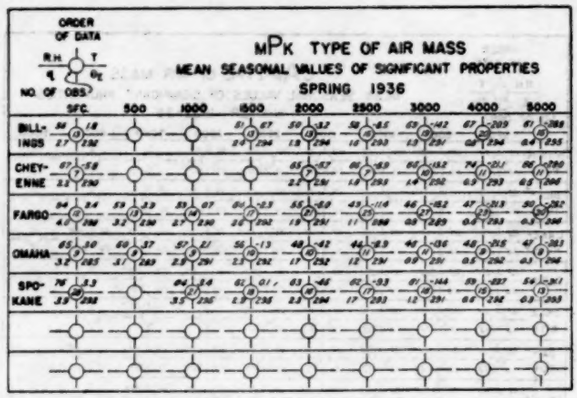
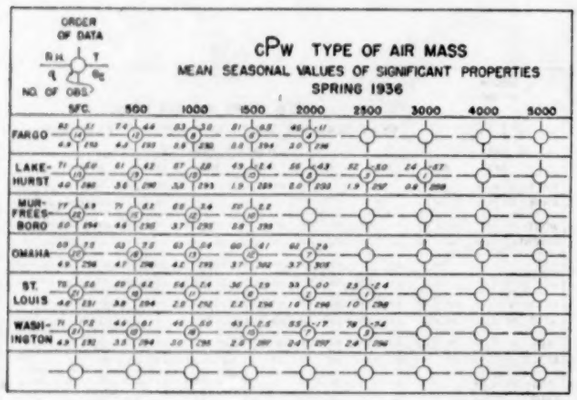
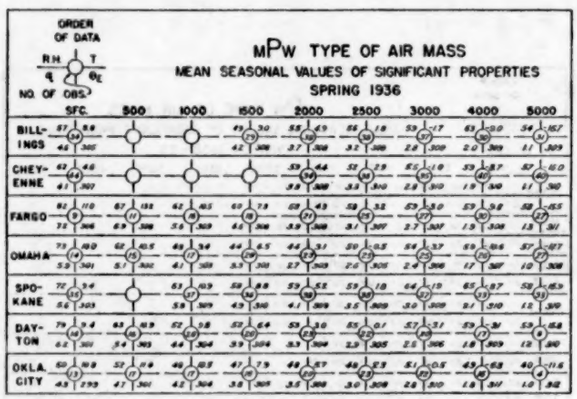


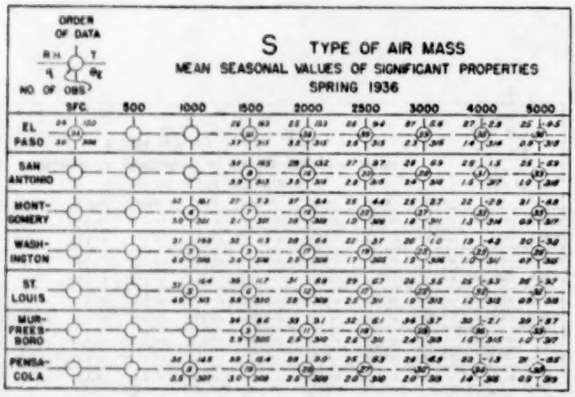
FIGURE 12.—Winter values of significant air-mass properties.











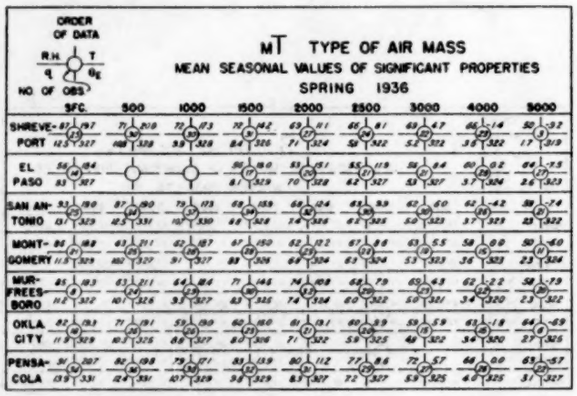
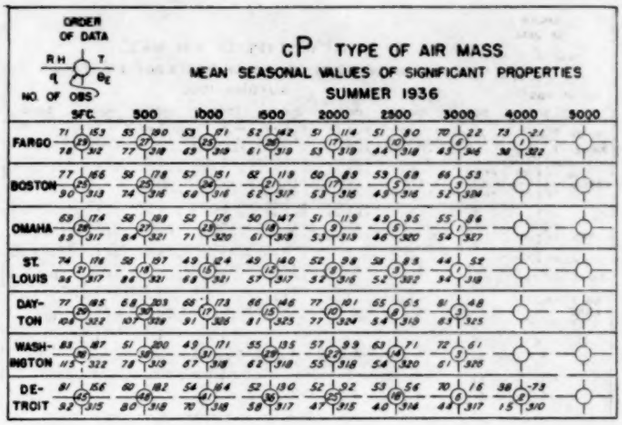
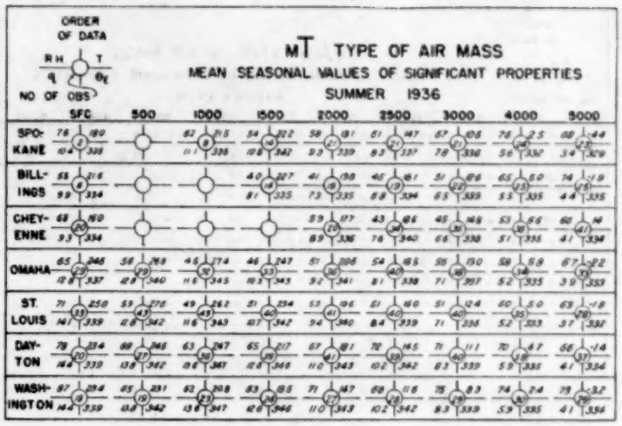
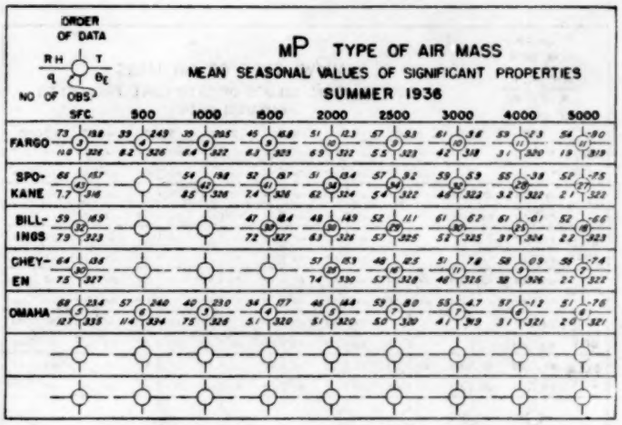
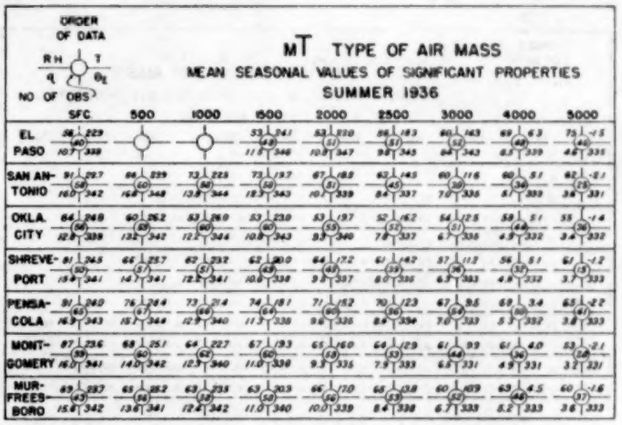


FIGURE 13.—Spring values of significant air-mass properties.









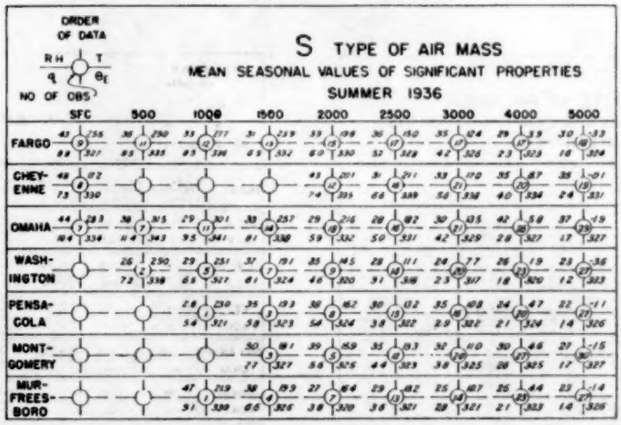
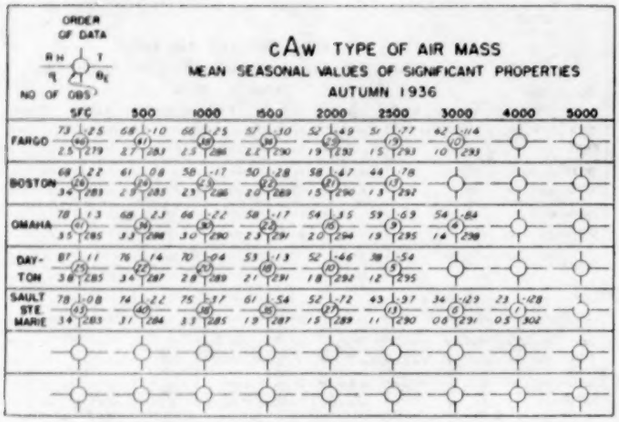
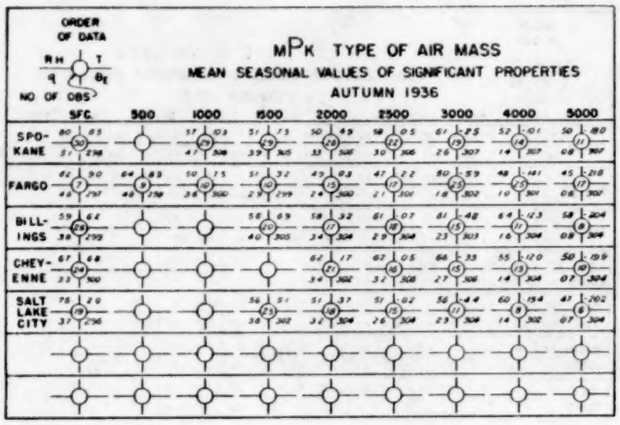
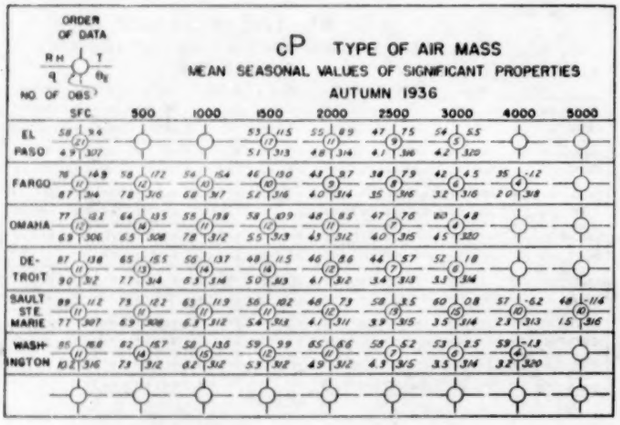
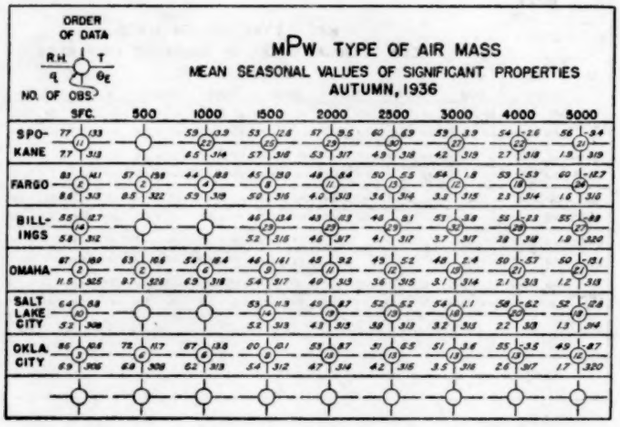


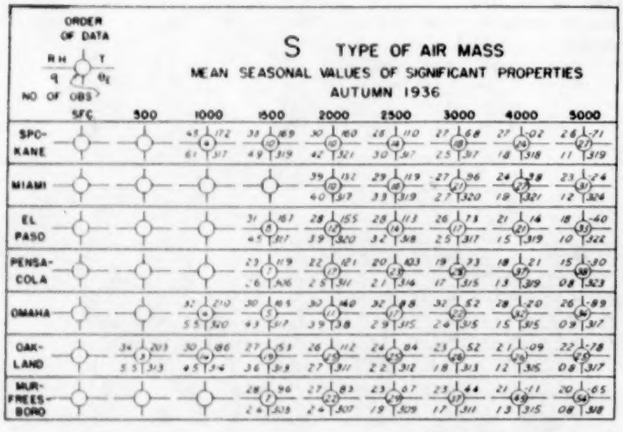
FIGURE 14.—Summer values of significant air-mass properties.











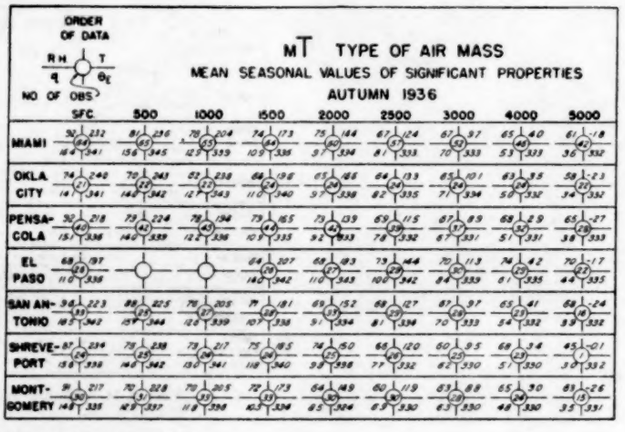


FIGURE 15.—Autumn values of significant air-mass properties.

number of types. The three main air masses, cA, mA, and mT have definite distinguishable properties; but the modified and mixed forms of these air masses may assume an entirely different set of characteristics. Further, since the relative dryness of an air mass is sometimes considered in its classification, the effects of pressure distribution alone may cause a change in label for the air mass.

The use of equivalent-potential temperature identifies the amount of heat and moisture in an air mass, and the relative humidity gives an indication of the degree of saturation. It has been suggested that a classification system be adopted using only the above two properties as arguments. The major objections to such a system are that the number of possible combinations becomes too large, it has no geographical significance, and it gives no indication of vertical stability. Therefore it seems advisable to continue the use of the three major types Pc, Pp, and TM, since they immediately convey indications of heat and moisture content and of vertical stability. In the wintertime the notations NPA, NPP, and NTM also appear satisfactory. TP is rare in occurrence in the United States, especially in the summer, and its properties must be very similar to TA air, so it seems advisable to use only the symbol TM for all tropical maritime air masses. PA is also rare at coastal stations but it often goes all the way around a Hudson Bay cyclone and enters the United States from the north. The characteristic properties of PA and PP should not be appreciably different, so only the symbol PM should be used in such cases since there is often a current of PP air flowing parallel to the PA current. Whenever there is reason to believe that Pc and any polar maritime air mass have been mixed by mechanical turbulence or by convection, the notation Pc should be used since most of the maritime characteristics have probably disappeared.

In midsummer all polar air masses are so rapidly modified over the continent that it seems advisable to use only the symbol NP for all polar air masses over the continental United States at that season. At all seasons when a polar air mass is rapidly assuming tropical maritime characteristics it is suggested that it be called NPM. A study of samplings of NPP→TP, NPP→TM, NP→TA, NP→TM, PA→NPA, NPC→TA, and NP→TA shows no definite distinguishable properties and all of these air masses can be called NPM and still have as much practical synoptic significance.

It seems necessary to continue the use of the symbol S to describe dry subsiding air masses. As soon as the air mass shows signs of being lifted the symbol S should be dropped since it would then be very misleading. The use of the notation NPS is suggested for polar air masses apparently in the early stages of subsidence.

In summary, the use of the following air mass types is considered of practical synoptic significance for the United States: For most of the year: Pc, PA, PP, PM, NPC, NPP, NPM, NPS, TM, and S. For midsummer: NP, NPM, NPS, TM, and S. However, since the above labels do not identify the stability of the lower levels of the air mass, it has been recommended that the differential classification of Bergeron be adopted as explained in an earlier paragraph.

THE AIR MASS CYCLE

Following the above-suggested classification it is possible to identify two distinct cycles of transition from polar to tropical air, one a moist cycle with rapid addition of moisture, the other a dry cycle with a marked subsidence and slow isentropic mixing in the early stages. An attempt to identify these cycles for the winter and summer seasons has been made on figures 8 to 11.

For the winter season the moist transitional stage, figure 8, from mP as represented at Dayton, to TM at Pensacola and St. Thomas, shows continual subsidence and increasing moisture. The persistent stability throughout the transitional process, the difference in potential temperature between 500 m. and 5,000 m. remaining practically constant from the mA to the TM stage, indicates that the principal addition of moisture must occur by means of mixing along isentropic surfaces, with some probability of convection in the final mT stage.

The dry winter cycle, figure 9, shows rapid subsidence with slight increase of moisture by isentropic mixing from the mA to the S stage. When this air mass moves to lower latitudes the subsidence decreases, rapid surface heating develops and the S air begins to mix both vertically and horizontally with mT air. The vertical mixing is probably confined to the lowest layers affected by daytime convection and most of the increase in moisture aloft appears to be due to isentropic mixing.

The identification of the moist and dry cycles is more difficult in the summer season because of the greater tendency for vertical convection during the day, with convection occurring under saturated conditions which cannot be analyzed by charts using potential temperature surfaces. However, the mean values, indicating unsaturated conditions, suggest for the moist cycle conditions similar to those observed in the winter season, namely, subsidence and surface heating with rapid increase of moisture by isentropic mixing.

The dry cycle for summer is more difficult to identify because the driest stage, S at Omaha, as shown in individual cases, is not clearly shown by the mean values for S at that station. In other words, some of the flights used in computing means for S air at Omaha may reprseent returning subsiding tropical maritime currents.

Examination of the mean isentropic chart for mT air in summer shows the tongue of air with highest moisture content to be probably subsiding as it moves northeastward from El Paso to Omaha. The apparent upward slope of the isentropic surfaces from Omaha to Pensacola is partly due to convergence and daytime convection over the Gulf coastal regions. The mT air at El Paso represents a more advanced stage of development than mT at Pensacola. The flow pattern suggested by the mean isentropic chart for summer mT indicates that the immediate trajectory of the mT air at El Paso is from the lower Caribbean area. The study indicates that appreciable quantities of heat and moisture may be added to mT air over the continental United States. The highest value of equivalent potential temperature, 366° A., observed during this study was found at 1,000 m. at Dayton on August 22, 1936.

The dry cycle in summer then represents rapid modification of the polar air masses with subsidence aloft and slow addition of moisture by isentropic mixing over the continent, then continued heating accompanied by vertical convection and convergence over the Gulf and Caribbean, followed by a slow spreading out and subsidence as the air assumes an anticyclonic trajectory on its return from the lower Caribbean to El Paso. From El Paso to the Mississippi Valley there is apparently a continued addition of heat and moisture and the mT air again becomes convectively unstable over the Mississippi and Ohio Valleys.

In the identification of air masses aloft in practical synoptic work it is recommended that attention be paid to the mean seasonal values for each of the principal air

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mass types and also to the probable range of equivalent-potential temperatures. In view of recent discoveries of the meteorological significance of isentropic charts it is further recommended that more attention be given to the slope of potential temperature surfaces in situations free from condensation. Allowance should be made for the possibility of horizontal mixing on isentropic surfaces and unless the isentropic surfaces in one air mass actually intersect the ground or at least show a sudden increase in slope, the synoptic analyst should label the air masses differently with caution.

BIBLIOGRAPHY

(1) Willet, H. C., *American Air Mass Properties.* Mass. Inst. of Tech. Papers in Physical Oceanography and Meteorology, vol. II, No. 2.

(2) Willet, H. C., *Definition of Ts as Employed by the Massachusetts Institute of Technology.*

(3) Bergeron, Tor. *Uber die dreidimensional verknüpfende Wetteranalyse.* Geofysiske Publikasjoner, vol. V. No. 6.

(4) Byers, H. R., *Synoptic and Aeronautical Meteorology.* McGraw-Hill, 1937.
Byers, H. R., *Characteristic Weather Phenomena of California.* M. I. T., Meteorological Papers, vol. I, No. 2.

(5) Wexler, H., *Cooling in the Lower Atmosphere and the Structure of Polar Continental Air.* MONTHLY WEATHER REVIEW, vol. 64, April 1936.

(6) Rossby, C.-G. and Collaborators, *Aerological Evidence of Large-Scale Mixing in the Atmosphere.* Transactions, American Geophysical Union, part I, Section of Meteorology, April 1937.
Rossby, C.-G. and Collaborators, *Isentropic Analysis.* Bulletin American Meteorological Society, vol. 18, June-July 1937.

(7) Pilot Charts of the North Pacific Ocean, U. S. Hydrographic Office.

(8) McDonald, W. F., and Showalter, A. K., *Air and Water Temperatures in the West Indian Region.* Transactions, American Geophysical Union, Section of Oceanography, April 1933.

(9) Deppermann, Rev. C. E., *The Upper Air at Manila.* Publications of the Manila Observatory, vol. II, No. 5.

(10) Rossby, C.-G., *Thermodynamics Applied to Air Mass Analysis.* M. I. T., Meteorological Papers, vol. I, No. 3.

NOTES AND REVIEWS

JOHN G. ALBRIGHT. *Physical Meteorology.* New York (Prentice-Hall), 1939. xxx, 392 pp., 246 figs.

This book, as implied by the title, emphasizes the physical rather than the descriptive or statistical aspects of meteorology; it is primarily an elementary exposition of the fundamental physical laws to which atmospheric phenomena conform, and an application of these laws to the explanation of the more important physical phenomena of the atmosphere. The book is intended as an introductory college textbook. It presupposes a working knowledge of physics, although a chapter on the principles of the theory of heat is included. The treatment is essentially nonmathematical, but a number of simple mathematical formulae are quoted and derivations are given for most of them.

The introductory chapter is devoted to a description of the scope of meteorology and its place among the sciences, with a brief historical sketch. After a chapter on the atmosphere in general, the succeeding chapters consider in detail, barometric pressure, temperature, insolation, and atmospheric water vapor. A chapter on the thermodynamics of the atmosphere includes a discussion of lapse rates and stability; and is followed by chapters on the wind, the dynamic theory of air movements, and a brief description of the planetary circulation. Consideration is next given to condensation, clouds, and the various forms of precipitation, followed by two chapters on tropical and extratropical cyclones, including a description of tornadoes and brief reference to the methods of air-mass analysis. The book is concluded by chapters on atmospheric electricity (including the aurora), thunderstorms and lightning, atmospheric acoustics, and atmospheric optics.—*Edgar W. Woolard.*

BIBLIOGRAPHY

[RICHMOND T. ZOCH, *in Charge of Library*]

By AMY P. LESHER

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Abbot, Charles Greeley.

Utilizing heat from the sun. Washington, D. C. 1939. 11 p. 4 pl., diagr. 24½ cm. (Smithsonian miscellaneous collections. v. 98, no. 5.) Publication 3530.

Brezina, E., & others.

Klima-Wetter-Mensch, von E. Brezina, W. Hellpach, R. Hesse, E. Martini, B. de Rudder, A. Schittenhelm, A. Seybold, L. Weickmann. Herausgegeben von Heinz Woltereck. Leipzig. 1938. 446 p. illus., maps, tabs., diagrs. 25½ cm.

Bullen, K. E.

A method of smoothing time series of data with application to annual rainfalls at Auckland, Wellington, N. Z. 1939. 139 B–144B p. tables, diagr. 28 cm. (Extracted from the New Zealand journal of science and technology. v. 20, no. 3B. 1938.)

Desaunais, A.

La crue de l'Ain et de la Valserine en Octobre 1935. [Lyon. 1938.] p. 88–92. map. 24½ cm. (From Les études rhodaniennes, Revue de géographie régionale, publiée à l'Institut des études rhodaniennes de l'Université de Lyon. v. 14, no. 1. 1938.)

The desert magazine. March, 1938. 1 v. 30 cm.

McKenney, J. Wilson. Yuma's sunshine reporter. p. 19, 26.

Eredia, Filippo.

Il clima, e, in particolare, le correnti aeree della Libia. Rome. 1937. 10 p. tables. 30½ cm.

Flaig, Walther.

Das Gletscherbuch. Rätsel und Romantik, Gestalt und Gesetz der Alpengletscher. Leipzig. 1938. 196 p. illus., plates, tables. 23½ cm.

Fotos, John Theodore, & Bray, John L.

German grammar for chemists and other science students; with simple graded readings based on vocabulary and syntax frequency studies. New York & London. 1938. xxii, 323 p. 21 cm.

France. Office national météorologique.

Note sur la protection météorologique des traversées aeriennes de l'Atlantique nord. [Paris.] 1939. 4 p. tab. (fold., laid in.) 31½ cm. [Mimeographed.]

Friez, Julien P., & sons, Baltimore, Md.

Friez weather instruments, accessories and parts, as listed on the General schedule of supplies, class 18, contract no. tps. 26484 for the period January 1 to December 31, 1939, and contract no. tps. 27866 for the period April 1 to December 31, 1939. [Baltimore. 1939.] 48 p. illus. 28 cm.

Gaines, Stanley Harry, comp.

Bibliography on soil erosion and soil and water conservation. With abstracts by Francesca Vincent, Marion Bloom, and James F. Carter. Washington. 1938. v., 651 p. 23½ cm. (U. S. Dept. of agriculture. Miscellaneous publication no. 312.) Contribution from Soil conservation service.

George, J. J., & Bradley, W. M.

The causes and forecasting of low ceilings and fogs at Atlanta airport. Atlanta. 1939. 47 p. maps, tables, diagrs. 28 cm. (Eastern air lines, inc., Meteorological dept.) [Mimeographed.]

Great Britain. Admiralty. Hydrographic dept.

Admiralty weather manual, 1938. London. 1938. 496 p. illus., plates, maps, tables, diagrs. 25 cm.

Italy. Ufficio idrografico del Po.

Lago di Como. Idrometro di Lecco Città (riva della Malpensata) effemeridi dal 1845 al 1930. Roma. 1936. unp. 1 pl., tabs. (part fold.) 35 cm. At head of title: Ministero dei lavori pubblici, Servizio idrografico, Ufficio idrografico del Po, Parma.

Johansson, Oscar Vilhelm.

Studien über die Homogenität der längeren Niederschlagsreihen in Europa. [Helsingfors, 1937.] 277 p. incl. tables. 23 cm. (Societas scientiarum fennica. Commentationes physico-mathematicae. ix, 13.)

Lange, Karl O.

The application of the Harvard radio meteorograph to a study of icing conditions. [New York. 1938.] p. 59–63. illus., diagrs. 30½ cm. (Reprinted from the Journal of the aeronautical sciences. v. 6, no. 2. December 1938.)

Lilian, Stan.

What's the weather up there? [Ketchikan, Alaska. 1938.] [8] p. illus. 30 cm. (From the Alaska sportsman, October 1938.)

Linke, F., editor.

Meteorologisches Taschenbuch. Dritte Ausgabe. Unter Mitarbeit von T. Bergeron, C. Kassner, K. Keil und K. Knoch. Herausgegeben von F. Linke. Leipzig. 1939. 268 p. illus., tables. 21 cm.

Livathinos, A. N.

Climatographie de la Grèce. C. Humidité de l'air. Athens. 1938. 82 p. maps, tables, diagrs. 26½ cm. [In Greek, with résumé in French.]

MacGregor, Clifford J.

Weather in the making. [New York. 1938.] p. 11–13. illus. 35½ cm. (From Collier's, v. 102. Dec. 24, 1938.)

MacTaggart-Cowan, P. D.

Transatlantic aviation and meteorology. [Toronto. 1938.] p. 217–231. illus., diagrs., maps. 26½ cm. (Reprinted from The journal of the Royal astronomical society of Canada, May–June, 1938. v. 32, no. 5.)

Maurain, Charles Honoré.

Étude pratique des rayonnements solaire, atmosphérique et terrestre (méthodes et résultats). Paris. 1937. 188 p. illus., tables, diagrs. 25 cm. Bibilographical footnotes.

Mindling, George W.

Weather man poems. Atlanta, Ga. 1939. [14] p. 28 cm. [Typewritten.]

Philippine Islands. Department of agriculture and commerce.

Climate of the Philippines. Manila. 1939. 31 p. map, tables, diagrs. 23½ cm.

Serra, Adalberto, & Serebrenick, Salamão.

Tabelas psicrométricas, organizadas por Adelberto Serra [&] Salamão Serebrenick. Rio de Janeiro. 1938. 102 p. tables. 32 cm. (Brasil. Ministério da viação e obras públicas. Departamento de aeronáutica civil. Divisão de meteorologia.)

Strouse, Solomon.

Weather and the human body. [Chicago. 1938.] [4] p. illus. 29½ cm. (From Hygeia, August, 1938.)

Tennessee Valley Authority.

Fifty inches of rain. A story of land and water conservation. [Washington. 1939.] 111 p. illus. (incl. map), tables, diagrs. 23½ cm.

SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, JULY 1939

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pages 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermophile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

During July, normal incidence intensities averaged below normal at Madison and Blue Hill and slightly above normal at Lincoln and Washington.

Total solar and sky radiation averaged above the May normals at all stations with the exception of Miami and Riverside.

Beginning with this issue data will be included in table 2 for Cambridge, Mass. These data are furnished through the cooperation of Massachusetts Institute of Technology; Prof. H. C. Hottel of the Department of Chemical Engineering has offered to supply these data regularly. The average daily total of solar radiation for the first week of record (June 25–July 1, 1939) was 426 gram-calories per square centimeter.

The data for Ithaca are not given in this issue because word was received from Prof. A. J. Heinicke of Cornell University that due to mechanical defects their values have been incorrect for the past several months. These data will be corrected and published later in this section of the MONTHLY WEATHER REVIEW.

TABLE 1.—*Solar radiation intensities during July 1939*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
July 1	14.10	.....	.....	1.04	1.18	1.37	.....	.....	.....	.....	11.38
July 11	10.21	0.74	0.84	.97	1.15	1.35	.....	.....	.....	.....	9.47
July 12	11.38	.51	.61	.77	.99	.....	.....	.....	.....	.....	11.81
July 15	9.14	.....	.....	1.02	1.28	.....	.....	.....	.....	.....	8.48
July 17	11.38	.....	.55	.68	.89	.....	.....	.....	.....	.....	10.21
July 31	15.65	.....	.49	.65	.91	.....	.....	.....	.....	.....	14.60
Means	.....	.62	.62	.86	1.07	(1.36)	.....	.....	.....	.....	.....
Departures	.....	+.03	−.06	+.05	+.15	+.14	.....	.....	.....	.....	.....

MADISON, WIS.

July 1	10.97	0.62	0.76	0.91	1.11	1.35	.....	.....	.....	.....	9.14
July 8	17.96	.65	.75	.94	.....	1.35	.....	.....	.....	.....	16.20
July 10	10.97	.65	.75	.80	1.08	1.37	.....	.....	.....	.....	9.47
July 11	11.81	.61	.70	.81	1.01	1.28	.....	.....	.....	.....	11.81
July 12	11.81	.45	.58	.75	.92	.....	.....	.....	.....	.....	15.11
July 13	19.23	.48	.58	.70	1.06	1.37	.....	.....	.....	.....	8.48
July 14	10.59	.68	.77	.95	1.16	1.40	.....	.....	.....	.....	10.21
July 20	10.97	.....	.....	.....	.86	.....	.....	.....	.....	.....	12.24
July 24	14.10	.61	.74	.88	1.07	1.31	.....	.....	.....	.....	9.83
July 26	16.79	.60	.69	.83	.....	.....	.....	.....	.....	.....	15.65
July 27	18.59	.65	.74	.87	1.08	1.25	.....	.....	.....	.....	17.37
July 29	10.21	.84	.92	1.04	1.18	.....	.....	.....	.....	.....	13.61
July 31	12.68	.69	.79	.90	1.11	1.28	0.99	.....	.....	.....	13.13
Means	.....	.63	.73	.86	1.06	1.33	(.99)	.....	.....	.....	.....
Departures	.....	−.05	−.05	−.05	−.01	+.03	+.01	.....	.....	.....	.....

TABLE 1.—*Solar radiation intensities during July 1939*—Continued

[Gram-calories per minute per square centimeter of normal surface]

LINCOLN, NEBR.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
July 5	16.79	.....	.....	0.72	0.92	.....	.....	.....	.....	.....	19.23
July 6	22.00	.....	.....	.....	1.06	1.37	0.98	0.78	.....	.....	21.28
July 7	17.37	.....	.....	.....	.....	.....	1.13	.....	.....	.....	18.59
July 8	16.79	.....	0.94	1.10	1.27	.....	.....	.....	.....	.....	11.81
July 10	13.13	.....	.89	1.01	.....	.....	1.11	.88	0.69	.....	10.97
July 14	12.68	.....	.....	.....	.....	.....	.....	.82	.66	.....	13.61
July 17	17.96	.....	.....	.....	.....	.....	1.04	.87	.72	.....	17.37
July 20	16.79	.....	.64	.77	.99	1.31	.....	.81	.66	.....	16.79
July 24	13.13	.....	.....	.....	.....	.....	1.04	.85	.68	.....	11.38
July 26	12.24	.....	.87	1.02	1.20	1.38	1.24	1.06	.93	.....	14.10
July 29	13.13	.....	.90	1.03	1.21	1.45	.....	.....	.....	.....	10.59
Means	.....	.....	.85	.94	1.11	1.38	1.09	.87	.72	.....	.....
Departures	.....	.....	+.06	+.02	+.02	+.04	+.02	−.02	−.04	.....	.....

BLUE HILL, MASS.

July 2	11.1	.....	.....	.....	1.07	.....	.....	.....	.....	.....	8.6
July 3	8.8	.....	.....	.....	1.12	1.40	.....	.....	.....	.....	7.6
July 4	11.9	.....	.....	.....	.....	.....	1.05	0.89	0.73	0.57	8.8
July 6	11.1	0.41	0.51	0.67	.....	.....	.....	.....	.....	.....	14.3
July 11	8.8	.....	.....	1.01	1.11	.....	.....	.....	.....	.....	9.9
July 13	7.6	.....	.....	.....	1.20	.....	.....	.....	.....	.....	8.2
July 15	10.7	.....	.....	.....	.....	.....	.....	.82	.67	.....	8.2
July 16	8.8	.....	.....	.....	1.08	.....	.....	.....	.....	.....	8.8
July 17	10.3	.....	.....	.80	.....	.....	.....	.....	.....	.....	10.7
July 18	9.9	.....	.....	.82	1.10	1.35	.....	.....	.....	.....	8.8
July 19	9.6	.....	.....	.....	.....	1.40	.....	.....	.....	.....	9.9
July 20	9.9	.....	.86	.....	.....	1.31	1.10	.....	.....	.....	9.6
July 21	10.7	.....	.87	.....	.....	.....	1.03	.87	.74	.65	10.7
July 24	14.3	.63	.70	.78	.....	.....	.....	.....	.....	.....	16.9
Means	.....	(.52)	.74	.82	1.11	1.36	1.06	.86	.71	(.61)	.....
Departures	.....	−.06	+.08	−.07	+.05	+.09	+.04	−.06	−.09	−.10	.....

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter: Washington	Madison	Lincoln	Chicago	New York	Fresno	Cambridge	Fairbanks	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Newport
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 2	565	577	632	540	556	.....	689	594	566	356	427	569	676	680	493	677
July 9	693	684	703	688	524	.....	607	377	574	411	391	552	678	664	571	594
July 16	404	467	507	511	540	737	617	496	586	477	430	546	670	623	646	679
July 23	477	568	649	472	399	661	418	412	630	536	352	514	492	713	714	435
	Departures of daily totals from normals															
July 2	+49	+41	+33	+63	+84	.....	.....	+132	−5	−122	+17	−35	+80	+60	−70	+127
July 9	+193	+141	+104	+217	+72	.....	.....	−95	−11	−95	−9	−33	+155	+50	−3	+52
July 16	−72	−58	−74	+46	+112	+34	.....	+60	+27	−34	+21	−14	+151	−1	+4	+168
July 23	−7	+52	+87	+1	−20	−2	.....	−37	+137	+22	−28	−27	+26	+93	+95	−44
	Accumulated departures since Jan. 1															
	+9,814	+6,692	+4,305	+10,507	+4,842	+322	.....	−49	+4,347	−700	+3,710	−1,820	+2,926	+6,284	+3,927	+1,827

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.) Superintendent, U. S. Naval Observatory. Data from measurements at the U. S. Naval Observatory from plates obtained at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's visible hemisphere. For each day, below longitude, latititude, area of spot or groups, and spot count, are given respectively the assumed longitude of the center of the disk, assumed latitude of the center of the disk, total area of spots and groups, and total spot count]

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1939	h m		°	°	°	°				
July 1	8 36	6522	−38	43	−7	39	121	15	G	Mount Wilson.
		(*)	−25	56	−24	36	48	6		
		6517	−11	70	−22	26	242	5		
		6523	−1	80	+16	14	36	4		
		6514	+1	82	−22	25	48	2		
		6509	+16	97	−6	18	145	18		
		6519	+24	105	−15	29	364	20		
		6508	+31	112	+4	31	97	3		
		6507	+34	115	−3	35	24	6		
		6518	+51	132	−15	34	73	5		
				(81)	(+3)		1,198	84		
July 2	11 10	6525	−88	338	−4	88	388	5	F	U. S. Naval.
		6522	−25	41	−9	27	145	12		
		6517	−11	55	−27	31	36	9		
		6524	−1	65	+15	12	6	1		
		6517	+3	69	−22	24	218	5		
		6523	+13	79	+15	17	24	1		
		6514	+15	81	−22	28	36	3		
		6509	+30	96	−6	32	97	15		
		6519	+33	99	−17	38	97	10		
		6519	+40	106	−14	43	194	8		
		6507	+43	109	−3	44	48	8		
		6508	+44	110	+4	44	97	2		
		6518	+66	132	−12	68	48	3		
		6518	+67	133	−15	69	6	2		
				(66)	(+3)		1,440	84		
July 3	10 33	6527	−80	333	−17	81	242	5	G	U. S. Naval.
		6526	−78	335	+16	79	48	8		
		6525	−75	338	−4	75	1,212	23		
		6522	−17	36	−10	20	6	5		
		6522	−11	42	−9	15	85	12		
		6517	+3	56	−26	29	36	10		
		6524	+12	65	+15	16	97	14		
		6517	+15	68	−22	28	242	6		
		6514	+28	81	−22	37	36	3		
		6509	+43	96	−7	45	97	10		
		6519	+46	99	−17	50	85	6		
		6519	+53	106	−15	57	194	4		
		6507	+58	111	−4	59	6	2		
		6508	+58	111	+5	58	109	3		
				(53)	(+3)		2,495	111		
July 4	10 50	6527	−67	333	−17	69	485	15	G	Do.
		6526	−63	337	+16	65	48	9		
		6525	−62	338	−5	63	1,600	78		
		6528	−25	15	+7	26	6	1		
		6522	+2	42	−9	12	121	20		
		6517	+15	55	−26	32	12	6		
		6524	+26	66	+15	28	73	10		
		6517	+28	68	−22	37	242	4		
		6514	+40	80	−22	46	24	7		
		6509	+57	97	−7	58	61	5		
		6519	+60	100	−17	63	61	5		
		6519	+68	108	−15	70	194	1		
		6508	+71	111	+5	71	61	1		
				(40)	(+3)		2,988	162		
July 5	8 32	6527	−56	332	−18	60	485	25	P	Mount Wilson.
		6526	−51	337	+16	52	12	1		
		6525	−48	340	−5	49	1,600	95		
		6528	−38	350	+7	39	97	10		
		6522	+15	43	−9	18	97	15		
		6517	+25	53	−26	37	12	8		
		6517	+39	67	−22	45	242	3		
		6524	+40	68	+15	42	48	2		
		6514	+52	80	−22	58	12	3		
		6509	+69	97	−6	70	73	2		
		6509	+70	98	−7	71	36	2		
		6519	+72	100	−17	75	48	4		
		6519	+80	108	−15	81	170	2		
		6508	+83	111	+5	83	48	1		
				(28)	(+3)		2,980	173		
July 6	11 38	6529	−63	310	+19	65	24	1	VG	U. S. Naval.
		6527	−40	333	−17	42	388	25		
		6525	−34	339	−6	34	1,648	78		
		6528	−23	350	+6	23	109	15		
		(*)	+18	31	−1	18	16	3		
		6522	+27	40	−7	28	12	4		
		(*)	+30	43	−10	33	48	1		
		6517	+41	54	−26	49	48	4		
		6517	+54	67	−23	59	291	7		
				(13)	(+3)		2,584	138		

See footnotes at end of table.

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1939	h m		°	°	°	°				
July 7	10 57	6529	−50	310	+20	51	12	1	F	U. S. Naval.
		6527	−27	333	−17	32	582	30		
		6525	−20	340	−6	22	1,939	90		
		6528	−8	352	+6	9	533	32		
		6530	+30	30	−2	30	16	4		
		6522	+40	40	−8	41	12	2		
		(*)	+42	42	−10	44	48	2		
		6517	+55	55	−26	61	24	2		
		6517	+68	68	−24	71	291	5		
				(360)	(+4)		3,457	168		
July 8	8 41	6532	−55	293	−16	58	16	2	F	Mount Wilson.
		6529	−38	310	+21	41	12	1		
		6531	−23	325	+17	26	12	2		
		6527	−13	335	−17	23	582	40		
		6525	−7	341	−5	10	1,454	75		
		6528	+5	353	+6	5	824	45		
		(*)	+20	8	+14	22	6	5		
		(*)	+22	10	+8	22	6	3		
		(*)	+35	23	+9	35	6	1		
		6522	+52	40	−8	53	12	1		
		6517	+78	66	−22	78	145	2		
				(348)	(+4)		3,075	177		
July 9	18 13	6532	−37	293	−17	41	48	8	F	Do.
		6527	+5	335	−17	22	582	55		
		6525	+12	342	−5	15	1,454	150		
		6528	+23	353	+6	23	1,164	95		
		6533	+37	7	+11	37	12	2		
				(330)	(+4)		3,260	310		
July 10	10 45	6532	−27	293	−17	32	48	11	VG	U. S. Naval.
		6527	+16	336	−17	25	582	56		
		6525	+21	341	−6	23	1,357	95		
		6528	+34	354	+6	33	1,164	80		
		6533	+47	7	+11	47	36	5		
				(320)	(+4)		3,187	247		
July 11	11 25	6535	−83	224	+17	81	1,164	96	G	Do.
		6532	−13	294	−18	25	170	24		
		6527	+30	337	−17	36	436	39		
		6525	+36	343	−6	38	1,115	75		
		6528	+48	355	+6	48	1,309	45		
		6534	+55	2	−17	58	24	6		
				(307)	(+4)		4,218	285		
July 12	11 4	6539	−85	209	+17	84	145	1	VG	Do.
		6535	−76	218	+17	74	48	3		
		6535	−69	225	+17	68	970	14		
		6538	−30	264	−8	32	6	2		
		6532	0	294	−18	22	133	18		
		6537	+2	296	+21	17	6	2		
		6536	+13	307	+18	20	73	9		
		6527	+40	334	−17	45	291	25		
		6525	+50	344	−6	50	921	45		
		6528	+61	355	+6	60	1,309	35		
		6534	+70	4	−16	72	6	1		
				(294)	(+4)		3,908	155		
July 13	11 17	6539	−71	209	+17	70	145	3	VG	Do.
		6535	−62	218	+17	62	48	3		
		6535	−55	225	+17	56	873	20		
		6540	−41	239	−15	45	24	6		
		6538	−19	261	−10	23	48	8		
		6532	+15	295	−18	26	48	12		
		6536	+27	307	+18	30	48	10		
		6527	+53	333	−17	56	194	9		
		6525	+63	343	−6	64	533	25		
		6528	+75	355	+6	74	1,212	20		
				(280)	(+4)		3,173	116		
July 14	11 8	6541	−74	193	+20	72	679	14	VG	Do.
		6539	−57	210	+17	58	145	2		
		6535	−48	219	+18	49	24	2		
		6535	−41	226	+18	43	388	35		
		6540	−26	241	−15	31	6	3		
		6538	−5	262	−9	14	97	11		
		6536	+40	307	+18	42	73	9		
		6527	+68	335	−18	70	145	6		
		6525	+76	343	−7	76	388	12		
		6528	+85	352	+5	85	485	7		
				(267)	(+4)		2,430	101		
July 15	10 48	6541	−62	192	+20	63	485	10	F	Do.
		6539	−44	210	+17	45	109	1		
		6535	−29	225	+17	32	824	15		
		6542	−20	234	+13	22	61	8		
		6538	+9	263	−10	15	97	12		
		6536	+53	307	+19	54	61	2		
		6527	+88	342	−17	89	145	1		
		6525	+88	342	−7	88	145	1		
				(254)	(+4)		1,927	50		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
July 16	11 38	6541	−48	193	+20	50	582	4	F	U. S. Naval.
		6539	−30	211	+17	32	109	1		
		6535	−16	225	+17	20	873	14		
		6542	−7	234	+13	11	242	16		
		6538	+20	261	−10	25	12	4		
		6536	+67	308	+19	69	12	2		
				(241)	(+4)		1,830	41		
July 17	10 53	6541	−35	193	+20	37	630	11	G	Do.
		6539	−17	211	+17	20	97	1		
		6535	−3	225	+17	12	679	12		
		6542	+7	235	+14	12	339	15		
		6538	+32	260	−10	35	12	2		
				(228)	(+5)		1,757	41		
July 18	8 36	6541	−24	192	+20	28	727	25	VG	Mount Wilson.
		6539	−6	210	+17	14	145	12		
		6535	+10	226	+17	16	679	45		
		6542	+20	236	+15	23	582	42		
				(216)	(+5)		2,133	124		
July 19	10 46	6541	−10	191	+20	18	679	45	VG	U. S. Naval.
		6539	+8	209	+17	15	145	16		
		6544	+22	223	−13	29	24	7		
		6535	+24	225	+17	26	679	35		
		(*)	+31	232	+25	36	24	8		
		6542	+35	236	+13	36	776	45		
				(201)	(+5)		2,327	166		
July 20	8 43	6546	−81	108	−12	82	48	1	VG	Mount Wilson.
		6545	−41	148	−9	44	97	10		
		6541	+3	192	+20	16	727	40		
		6539	+21	210	+17	24	145	12		
		6544	+36	225	−13	40	36	5		
		6535	+37	226	+17	38	679	20		
		6542	+45	234	+13	46	776	30		
				(189)	(+5)		2,508	118		
July 21	15 34	6547	−73	99	+6	75	97	1	G	U. S. Naval.
		6546	−65	107	−14	68	36	1		
		6545	−24	148	−9	27	170	12		
		6541	+20	192	+19	25	679	35		
		6539	+39	211	+17	41	145	10		
		6535	+52	224	+17	53	485	9		
		6542	+66	238	+13	68	339	15		
				(172)	(+5)		1,951	83		
July 23	9 10	6547	−48	101	+7	48	97	8	F	Mount Wilson.
		6546	−39	110	−13	43	24	1		
		6545	+3	152	−8	13	436	28		
		6541	+44	193	+20	46	291	26		
		6539	+62	211	+17	64	73	10		
		6535	+78	227	+17	78	339	4		
		6542	+85	234	+13	85	48	2		
				(149)	(+5)		1,308	79		
July 24	10 35	6547	−35	100	+7	35	73	1	F	U. S. Naval.
		6546	−25	110	−14	31	12	4		
		6545	+15	150	−8	20	436	20		
		6541	+57	192	+19	59	97	11		
		6539	+70	205	+17	72	12	1		
		6548	+78	213	+4	79	6	1		
				(135)	(+5)		636	38		
July 25	11 48	6550	−61	60	−22	66	36	2	F	Do.
		6547	−20	101	+6	20	97	3		
		6546	−14	107	−16	25	6	1		
		6549	−7	114	−6	12	48	4		
		6545	+30	151	−9	33	679	19		
		6541	+70	191	+19	72	12	2		
				(121)	(+5)		878	31		
July 26	13 9	6550	−48	59	−22	54	36	6	VG	Do.
		6547	−7	100	+6	7	121	8		
		6549	+7	114	−5	11	36	3		
		6545	+44	151	−9	46	727	36		
				(107)	(+5)		920	53		
July 27	11 7	6550	−33	62	−22	42	24	1	VG	Do.
		6547	+8	103	+6	9	121	4		
		(*)	+21	116	+15	23	6	1		
		6549	+22	117	−5	24	61	3		
		6545	+56	151	−9	58	727	34		
				(95)	(+5)		939	43		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
July 28	11 20	6553	−83	359	+8	83	776	1	G	U. S. Naval.
		6552	−19	63	−22	32	36	2		
		6550	−9	73	−24	29	73	7		
		6547	+23	105	+6	23	73	1		
		6549	+37	119	−5	38	48	4		
		6551	+43	125	−32	55	145	14		
		6545	+71	153	−9	73	824	20		
				(+82)	(+5)		1,975	49		
July 29	11 6	6553	−69	0	+8	71	630	1	VG	Do.
		6554	−24	45	−17	33	6	4		
		6550	−4	65	−23	29	36	6		
		6547	+37	106	+7	37	61	5		
		6549	+50	119	−4	51	36	6		
		6551	+56	125	−33	68	436	11		
		6545	+85	154	−9	86	533	4		
				(69)	(+6)		1,738	37		
July 30	9 15	6553	−57	0	+8	58	582	7	G	Mount Wilson.
		6554	−12	45	−17	25	12	2		
		6555	−5	52	−19	26	12	2		
		6552	+3	60	−20	26	12	2		
		6550	+15	72	−23	32	97	10		
		6547	+50	107	+7	50	48	1		
		6551	+63	120	−33	73	97	2		
		6549	+64	121	−3	65	24	1		
		6551	+73	130	−30	80	170	2		
				(57)	(+6)		1,054	29		
July 31	10 51	6557	−85	318	+14	85	339	3	G	U. S. Naval.
		6556	−67	336	−15	70	194	12		
		6553	−43	0	+8	43	582	4		
		6555	+14	57	−22	30	12	3		
		6552	+19	62	−19	31	48	8		
		6550	+28	72	−23	41	145	15		
		6547	+64	107	+6	64	48	1		
		6551	+77	120	−32	83	24	2		
		6549	+77	120	−3	78	6	1		
				(43)	(+6)		1,398	49		

Mean daily area for 30 days=2,189.

* Not numbered.
Plate quality: P, poor; F, fair; G, good; VG, very good.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR JULY 1939

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen, Sternwarte, Zurich Switzerland]

July 1939	Relative numbers	July 1939	Relative numbers	July 1939	Relative numbers
1	103	11	*d* 131	21	106
2	*a* 97	12	118	22	
3	*dd* 112	13	101	23	*a* 80
4	*Ec* 128	14	*d* 97	24	67
5	130	15	*Mc* 87	25	62
6	122	16		26	53
7	151	17	*ab* 85	27	*a* 51
8	*ab* 167	18	86	28	*Wcd* 58
9	*ab* 130	19	*a* 95	29	*Mc* 71
10	143	20	*Ebc* 113	30	68
				31	47

Mean, 29 days 98.6.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: *E*, on the eastern part of the sun's disk; *W*, on the western part; *M*, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. Little in charge]

By B. Francis Dashiell

Note.—The text and tables for this section will be published in a later issue of the Review.—*Ed.*

RIVERS AND FLOODS

[River and Flood Division, Merrill Bernard in Charge]

By Thomas S. Southwick

Rainfall during June was generally above normal in the eastern part of the country except for the Northeast. Rainfall was much less abundant in July, above normal rainfall occurring only in the Ohio Valley region, portions of the south Atlantic coast and the Far West. In the Northeast, rainfall was very scanty and streams in New England were at quite low stages.

Floods were not numerous nor especially severe except for an extraordinary "flash" flood in Kentucky early in July. The floods during June and July were generally the result of locally intense rainstorms characteristic of summer. Flood stages were usually of short duration and of local extent except in the low lying rivers of the lower Mississippi basin.

Detailed damage figures are given in a table at the end of this article.

Atlantic Slope drainage.—Locally heavy rains occurred over the South Atlantic States from July 19 to 22 in association with frontal activity. Streams were at fairly low stages and flood stage was exceeded only on the Cape Fear and Neuse Rivers. Flooding was slight with practically no damage.

East Gulf of Mexico drainage.—High stages continued to prevail on the Tombigbee River with flood stage being attained during the first week in June at some stations and throughout its length at various dates from June 16 to 28. These floods were the result of the rises of May occasioned by the heavy rains during the last 2 weeks of May, augmented by the rainfall from frequent and widely distributed thundershowers of June. Stages were moderate on the Tombigbee, although extreme stages were reported on some of the Northeastern tributaries. However, these floods, occurring as they did during the growing season, caused widespread damage, estimated at over 3 millions of dollars. Approximately 200,000 acres of land were inundated.

The Bogue Chitto and Pearl Rivers went above flood stage early in June. Stages and consequent damage were moderate.

Mississippi System—Upper Mississippi Basin.—A progression of lows across the basin from June 11 to 22 resulted in enough rainfall to raise the streams, but the only flood situation was in the lower Chippewa River. The river at Durand, Wis., was only slightly above flood stage on June 22 and 23, and only slight damage resulted from the flooding of basements.

In northeastern Missouri the passing of a low resulted in heavy and fairly widespread rains on the night of June 20–21. This rain caused a rapid rise in the Salt River which resulted in the flooding of considerable farm land and extensive damage to crops and other farm property.

The Salt River went slightly above flood stage on July 26 as the result of thunderstorm rains. There was nominal damage to prospective crops.

Heavy showers resulted in the Republican, Big Blue, and Grand Rivers going above floodstage during the period June 22 to 28. Except for the lower reaches of the Grand River, the period above flood stage at each point was only 1 or 2 days. Stages were slight to moderate with little damage reported.

In July, local rains caused slight flooding at Chillicothe, Mo., on the Grand River on the 5th and at Beloit, Kans., on the Solomon River on the 27th. There was no damage.

Ohio Basin.—Cyclonic development over Ohio on June 18 caused heavy showers in the upper portions of the Scioto and Olentangy Rivers. The rainfall averaged between 4 and 5 inches, but the low stages prevailing at the time caused only minor flooding to take place. There was some damage to prospective crops.

A local, but devastating "flash" flood occurred in eastern Kentucky on July 5. Very heavy rains resulted from thunderstorms associated with a cold front. The towns of Farmers, Clearfield, Morehead, and Keck were inundated by the sudden overflow. There were 79 lives lost according to the American Red Cross. The flood occurred on small streams on which the Weather Bureau does not maintain river gages; hence no stages are listed. This disastrous flood is described by W. C. Devereaux, official in charge at the Cincinnati, Ohio Weather Bureau Office as follows:

> Torrential rains, varying in amount from 2.5 inches to more than 9 inches, fell in a few hours over portions of eastern Kentucky during the night of July 4–5, 1939. The topography of this section of the State is mountainous. The mountain ranges extend in a northeast-southwest direction and are separated from each other by deep and narrow valleys. It is therefore not surprising that rainfalls of the proportions mentioned above, falling in from 2½ to 4 hours, should cause the normally placid creeks and small streams to become raging torrents causing destruction to life and property. The floods were nearly all confined to the creeks and small streams entering the upper Licking and upper Kentucky Rivers. The only river gaging station on the Licking River in this district to report flood conditions was at Farmers, Ky., where a crest of 25.25 feet was recorded at 10:06 a. m., on July 5th, 0.25 foot, above flood. At Jackson on the upper Kentucky River 3.75 inches of rain fell between 3:15 a. m. and 8 a. m. on July 5th. The crest stage of the river was 20.40 feet, at 6 p. m. on the 5th (flood stage 28 feet).

Heavy rainfall associated with a low that traversed Indiana on the night of July 17–18 resulted in one of the flashiest floods of record in the middle upper reaches of the Wabash River. Rainfall amounts, in a relatively small area centered over Covington, Ind., averaged 3 inches. The Wabash River at Covington rose 11.6 feet in 24 hours, but fortunately the local extent of the rain and the low summer stages then prevailing prevented other than minor flooding. Moderate damage was reported.

White, Arkansas, and Red River Basins.—The White River below Georgetown, Ark., was slightly above flood stage at the beginning of June from the rains of April and May. Moderate stages on the lower Mississippi River during the first half of May delayed run-off in the lower White River. This condition, augmented by normal rainfall during May and early June, maintained the river above flood stage for about 2 weeks. Little damage was reported.

Heavy rains over the North and South Canadian Rivers during the last 10 days of June caused flash floods at several localities. Moderate damage was reported. The North Canadian River at Canton, Okla., went slightly above flood stage again on July 4.

The Sulphur River at Ringo Crossing, Tex., went slightly above flood stage on June 2, as the result of moderate local rains.

Lower Mississippi Basin.—The Coldwater River at Coldwater, Miss., went slightly above flood stage from June 13 to 16 and again from July 4 to 6 as the result of local rains.

The Tallahatchie River rose above flood stage at Swan Lake, Miss., on June 25 from moderate rains and remained above flood stage until July 12. The crest stage of 28.5 feet was not excessive, but a considerable acreage was flooded. This overflow, coming as it did during the growing season, resulted in an appreciable amount of damage.

West Gulf of Mexico drainage.—Heavy rains over a portion of the upper watershed of the Colorado River caused flash floods at Snyder, Tex., and Colorado City, Tex., on June 20 and 21. As the Weather Bureau does not maintain any river gages in this section no stages are listed. Damage was extensive, a railroad bridge, 8 tank cars and a number of houses being demolished. The flood water was impounded above Buchanan Dam, and stages downstream changed but little.

Correction.—In the March 1939 issue of the MONTHLY WEATHER REVIEW, on page 74, in the description of the Ohio River flood, it was incorrectly stated that higher stages were reached on the Walhonding River than in 1937. The crest stage at Walhonding, Ohio, was 16.2 feet on March 13, 1939, as compared with a crest of 16.9 feet on January 15, 1937.

Flood damage—June–July 1939

Drainage and river	Tangible property	Matured crops	Prospective crops	Livestock and other movable property	Suspension of business	Total
EAST GULF OF MEXICO DRAINAGE						
Tombigbee						[1] $3,500,000
Pearl	$5,000	$1,000			$5,000	11,000
MISSISSIPPI SYSTEM						
Upper Mississippi Basin						
Chippewa	1,645					1,645
Salt			$70,000		5,500	75,500
Missouri Basin						
Republican		5,000				5,000
Big Blue	8,500					8,500
Ohio Basin						
Olentangy			10,000			10,000
Scioto			52,000			52,000
Wabash	10,000	3,000	2,600	$500		16,100
White Basin						
White [2]			6,600	500		7,100
Arkansas Basin						
North Canadian	14,800	7,500	22,950			42,250
South Canadian	28,000	4,100	4,000			36,100
Lower Mississippi Basin						
Tallahatchie			125,000			125,000
WEST GULF OF MEXICO DRAINAGE						
Colorado	350,000					350,000

[1] Survey by United States engineers; includes floods of May 1939.
[2] Includes damage for April and May.

Table of flood stages during June and July 1939

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
Cape Fear: Lock No. 2, Elizabethtown, N. C	*Feet* 20	July 23	July 23	*Feet* 22.0	July 23.
Neuse:					
Smithfield, N. C	13	July 21	...do	14.0	July 22.
Goldsboro, N. C	14	July 24	July 27	15.4	July 26.
EAST GULF OF MEXICO DRAINAGE					
Tombigbee:					
Aberdeen, Miss	34	June 19	June 22	37.0	June 20.
Lock No. 4, Demopolis, Ala	39	June 3	June 7	41.4	June 5.
		June 19	June 25	43.7	June 22.
Lock No. 3, Ala	33	May 31	June 13	43.4	June 5.
		June 16	June 20	45.7	June 22.
Lock No. 2, Ala	46	June 20	June 24	46.9	June 23.
Lock No. 1, Ala	31	June 3	June 13	32.8	June 9.
		June 20	June 28	32.8	June 24–25.
Bogue Chitto: Franklinton, Ala	11	June 4	June 6	13.6	June 4.
Pearl: Pearl River, La	12	June 1	June 14	15.6	June 8.
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Chippewa: Durand, Wis	11	June 22	June 23	11.4	June 22.
Salt: New London, Mo	19	June 21	...do	22.5	Do.
		July 26	July 26	20.6	July 26.
Missouri Basin					
Solomon: Beloit, Kans	18	July 27	July 27	18.6	July 27.
Republican:					
Guide Rock, Nebr	9	June 22	June 23	9.4	June 22.
Scandia, Kans	9	June 23	...do	9.4	June 23.
Concordia, Kans	8	...do	...do	8.0	Do.
Big Blue: Randolph, Kans	19	June 26	June 26	19.8	June 26.
Grand:					
Gallatin, Mo	20	June 22	June 23	22.1	June 23.
Chillicothe, Mo	18	June 21	June 24	26.6	Do.
		July 5	July 5	19.1	July 5.
Brunswick, Mo	12	June 21	June 28	15.4	June 25.
Ohio Basin					
Olentangy: Delaware, Ohio	9	June 18	June 20	14.0	June 19.
Scioto:					
La Rue, Ohio	11	June 20	...do	11.8	June 20.
Prospect, Ohio	10	June 21	June 21	10.0	June 21.
Chillicothe, Ohio	16	...do	June 22	17.4	June 22.
Wabash:					
Covington, Ind	16	July 18	July 18	16.4	July 18.
Terre Haute, Ind	14	July 20	July 20	14.1	July 20.
White Basin					
White:					
Georgetown, Ark	21	May 19	June 7	23.0	June 1–2.
Clarendon, Ark	26	May 26	June 14	27.8	June 5–6.
St. Charles, Ark	25	June 1	June 15	25.8	June 6–9.
Arkansas Basin					
North Canadian:					
Woodward, Okla	5	June 25	June 25	5.4	June 25.
Canton, Okla	9	...do	June 26	10.0	June 26.
		July 4	July 4	9.3	July 4.
Yukon, Okla	8	June 24	July 18	12.6	June 28; July 6.
East Oklahoma City, Okla	14	June 28	June 29	15.0	June 28.
Red Basin					
Sulphur: Ringo Crossing, Tex	18	June 2	June 2	20.6	June 2.
Lower Mississippi Basin					
Coldwater: Coldwater, Miss	13	June 13	June 16	13.6	June 15.
		July 4	July 6	13.5	July 5.
Tallahatchie: Swan Lake, Miss	26	June 25	July 12	28.5	July 1–2.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL, in Charge]

NORTH ATLANTIC OCEAN, JULY 1939

By H. C. HUNTER

Atmospheric pressure.—During July pressure averaged above normal over northwestern and north-central and over much of the southeastern portions of the North Atlantic; but it averaged below normal over the southwestern and south-central areas, and especially also over waters near the British Isles, where the deficiency at Valencia, Ireland, was quite large for the season.

This was the first month since January in which the pressure exceeded normal over waters around southern Greenland, and likewise in which the pressure was appreciably lower than normal near the southeastern United States and the northern West Indies. It was the first since February in which the vicinity of the British Isles had pressure less than normal.

The extremes of pressure noted in available vessel reports were 1,036.0 and 990.9 millibars (30.59 and 29.26 inches, respectively). The higher reading was noted by an unidentified vessel during the forenoon of the 2d nearly 900 miles west of Horta, Azores Islands. From the 19th to 22d pressure again was comparatively high over and to northwestward and westward of the Azores. The low mark was recorded on the Dutch steamship *Colytto*, just before noon of the 14th, when the vessel was about 130 miles to southward of the southern tip of Ireland.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, July 1939*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Julianehaab, Greenland	1,013.1	+4.0	1,020	12	998	31
Reykjavik, Iceland	1,012.6	+2.1	1,021	15	999	22
Lerwick, Shetland Islands	1,007.1	−2.0	1,019	4	993	17
Valencia, Ireland	1,010.5	−5.3	1,028	10	998	14
Lisbon, Portugal	1,017.4	+.8	1,022	1, 9, 22, 31	1,010	3
Madeira	1,019.5	+1.9	1,028	22	1,016	27
Horta, Azores	1,024.2	−.9	1,032	22	1,015	3
Belle Isle, Newfoundland [1]	1,014.2	+2.0	1,029	20	1,002	9
Halifax, Nova Scotia	1,015.8	+1.6	1,023	22, 28, 29	1,005	8
Nantucket	1,015.1	−.1	1,026	21	1,005	15
Hatteras	1,016.0	−.3	1,022	3	1,007	15
Bermuda	1,020.1	−1.9	1,024	7	1,015	14
Turks Island	1,017.6	−.7	1,019	1-3, 11, 21, 22, 26	1,015	5-7, 28
Key West	1,015.9	−1.0	1,020	31	1,012	8
New Orleans	1,015.8	−.1	1,021	26	1,008	9

[1] For 26 days.

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales of the main North Atlantic.—The month was comparatively uneventful, even for summer. Two vessels reported strong gales (force 9), when near southern Ireland, the dates being not far from the middle of the month. Each of these gales was connected with the persistent area of low pressure which remained in the region of the British Isles from the 12th to the 20th, varying in strength from day to day.

Over waters not far to the eastward of the United States coast fresh gales were occasionally encountered, especially about the 9th and 10th and about the 20th and 21st.

Disturbance over Gulf of Mexico.—While one instance of a force 7 wind in the Caribbean has come to notice (see report of the steamship *American Press* in the accompanying table), no cyclonic circulation over those waters seems to have occurred at any time during the month. In the Gulf of Mexico, however, there was one area of low pressure with well-formed circulation.

On the morning of the 7th this Gulf disturbance was definitely indicated, the center being 200 miles or slightly less to westward or west-southwestward of Tampa. Without attaining more than slight strength, the disturbance traveled westward, rather rapidly till the 9th, then more slowly, till it passed inland near Corpus Christi, Tex., during the night of the 11th–12th. There seems to have been no wind force as high as 8 connected with this disturbance at any stage of its life. The only report by mail of force 7 (American steamship *Comayagua*) is shown in the table, likewise the report of the American motorship *Rhode Island*, which noted the lowest pressure connected with the disturbance, 1,006.4 millibars (29.72 inches).

Fog.—Fog continued to occur frequently over many areas to northward of the 40th parallel, while near New Jersey, Delaware Bay, and the Chesapeake capes there was very much less than during June. Compared with the average July situation, the fogginess of the current July was somewhat greater than usual over the southern Grand Banks, but less than usual over waters close to Newfoundland, also near Ireland.

For the southern Grand Banks area there were two adjoining 5° squares, each showing 19 days of fog. These lie between 40° and 45° N., 45° and 55° W. There were but very few days before the 17th when fog did not occur in that area.

Only one other North Atlantic 5° square even closely approached this count of 19 days, and that was the square close to western Nova Scotia and eastern New England, 40° to 45° N., 65° to 70° W., where 20 days were foggy. Here the final decade of the month had the greater number of foggy days. Along and near the Massachusetts coast fog was particularly dense about the 23d, but reports at hand show no very serious accidents resulting.

The leading square of the eastern half of the North Atlantic, as far as available reports show, was that from 45° to 50° N., 20° to 25° W., with a count of 10 days. Over this and nearby areas the week from 20th to 26th was the foggiest part of the month.

OCEAN GALES AND STORMS, JULY 1939

Vessel	Voyage		Position at time of lowest barometer		Gale began July	Time of lowest barometer, July	Gale ended July	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Europe, Nor. M. S.	Antwerp	New York	50 20 N.	1 22 W.	6	Noon, 5.	6	1007.1		WSW, 5.		SW, 8.	
Bruxelles, Belg. S. S.	Galveston	Havre	37 36 N.	66 12 W.	9	8a, 9	10	1019.6	W	W, 8		W, 8	
Alfred Olsen, Nor. M. S.	Copenhagen	Philadelphia	37 24 N.	64 12 W.	10	8a, 10	10	1019.0		SW, 8		SW, 8	
Rhode Island, Am. M. S.	Port Arthur	New York	[1] 28 21 N.	91 16 W.	10	8a, 10	10	1006.4		S, 5		S, 6	SSW-S.
Comayagua, Am. S. S.	Galveston	Tuxpam	27 42 N.	95 06 W.	11	6p, 11	12	1011.2	SE	SE, 6	SSE	SSE, 7	SE-SSE.
Colytto, Du. S. S.	Rotterdam	Wabana	49 48 N.	8 00 W.	14	Noon, 14	16	990.9	NNW	W, 5	NNW	NW, 9	W-NW.
Bennekom, Du. S. S.	Curacao	Liverpool	51 18 N.	7 48 W.	15	Noon. 16	15	1001.4		N, 5		N, 8	
Braheholm, Swed. S. S.	Gdynia	New York	59 31 N.	6 17 W.	17	8a, 17	18	991.5	N	N	N	N, 8	N-NNE.
American Press, Am. S. S.	Pto. Colombia	Houston	11 42 N.	75 48 W.	19	7p, 19	20	1008.5	ENE	ENE, 7	ENE	ENE, 7	
Bruxelles, Belg. S. S.	Galveston	Havre	49 24 N.	10 54 W.	16	11a, 20	20	1016.3		NW, 8		NW, 9	
Isabela, Am. S. S.	New Orleans	San Juan	[1] 20 14 N.	71 26 W.	20	4p, 20	20	1014.6	E	ESE, 7	ESE	E, 7	E-ESE.
Black Gull, Am. S. S.	Antwerp	New York	41 43 N.	56 57 W.	20	4a, 21	21	1007.8	SE	S, 8	NW	SE, 8	SE-SW.
Volunteer, Am. S. S.	Port Arthur	Avonmouth	40 53 N.	56 17 W.	20	6a, 21	21	1010.5	SW	SW, 6	SW	SW, 8	None.
Braheholm, Swed. S. S.	Gdynia	New York	44 32 N.	52 10 W.	25	4p, 25	26	1002.7	NNE	SSW	N	NNE, 8	SSW-NE.
Realf, Nor. M. S.	Copenhagen	Philadelphia	49 45 N.	10 54 W.	27	Noon,28	28	1010.5	SW	WSW, 8	W	SW, 8	SSW-WSW.
NORTH PACIFIC OCEAN													
Lacklan, Br. S. S.	Shanghai	Los Angeles	32 30 N.	125 25 E.	9	1p, 9	9	968.8	NE	NW, 4	SW	NE, 12	NE-NW-SW.
Arizona, U. S. N.	San Francisco	Tacoma	38 00 N.	123 20 W.	17	3p, 17	18	982.1	NW	NW, 8	NNW	NNW, 8.	NW-NNW.
Silveray, Br. M. S.	Cape Engano, P. I.	Los Angeles	24 38 N.	129 54 E.	18	10a, 18	19	996.3	NE	SSE, 5	SE	SE, 8	NE-SSE-SE.
Thor I, Nor. M. S.	Samoa	Mazatlan	17 30 N.	118 40 W.	19	10a, 19	19	1000.7	NNE	S, 5	SE	NNE, 7	NE-S-SSE.
Knoxville City, Am. S. S.	Honolulu	Balboa	6 36 N.	97 36 W.	22	4a, 23	23	1009.5	SW	S, 7	S	S, 7	
Evita, Nor. M. S.	Saigon	Los Angeles	25 01 N.	128 28 E.	23	2a, 24	24	1005.1	SE	SSE, 9	SSE	SSE, 9	SSE-SW.
Susan V. Luckenbach, Am. S. S.	Los Angeles	Balboa	18 03 N.	103 21 W.	29	Noon, 29.	29	1006.8	WSW	E, 9	SE	E, 9	NE-SE.

[1] Position approximate.

NORTH PACIFIC OCEAN, JULY 1939

By Willis E. Hurd

Atmospheric pressure.—The average pressure chart of the North Pacific Ocean for July 1939 shows two distinct depressions—one of them, the Aleutian LOW, central over the eastern part of the Bering Sea; the other, off the east coast of China. In both instances the central pressures were below the normal of the month by some 2 to 3 millibars (0.06 to 0.09 inch). At St. Paul Island the July average, 1,007.8 millibars (29.76 inches) was 5.1 millibars (0.15 inch) below the previous June average, thus indicating an unusual strengthening, instead of the usual weakening, of the Aleutian LOW in this summer month.

Practically throughout July the North Pacific HIGH extended from the California coast westward far into east longitudes. At Midway Island the average pressure, 1,022.8 millibars (30.20 inches), was 3.2 millibars (0.09 inch) above the normal of the month.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, July 1939, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow	1,012.1	−0.9	1,020	8	1,007	14, 30
Dutch Harbor	1,010.7	−3.3	1,024	9	994	1
St. Paul	1,007.8	−2.7	1,020	9	992	20, 21
Kodiak	1,011.4	−2.6	1,024	8	988	31
Juneau	1,015.8	−1.9	1,027	20	1,002	3
Tatoosh Island	1,018.8	+1.1	1,029	20	1,004	2
San Francisco	1,014.8	+0.5	1,021	11	1,008	24
Mazatlan	1,011.9	+0.9	1,014	4, 15	1,010	23, 31
Honolulu	1,017.4	+0.7	1,021	16	1,014	29
Midway Island	1,022.8	+3.2	1,026	9, 15–17	1,018	14
Guam	1,009.2	−1.1	1,012	15, 22	1,007	20, 25, 30
Manila	1,006.4	−0.6	1,009	1, 24–26	1,002	31
Hong Kong	1,001.0	−3.1	1,009	1	995	29
Naha	1,004.0	−2.3	1,013	1	995	31
Titijima	1,010.1	−0.6	1,016	3, 12–17	1,002	1, 27, 30
Petropavlovsk	[1]	[1]	[1]	[1]	[1]	[1]

[1] Data missing.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Extratropical cyclones and gales.—In northern and middle latitudes the North Pacific weather in July 1939 appears to have been record-breaking in its lack of winds of gale force due to extratropical conditions. There were northerly gales of force 8 to 9 off the central California coast on the 17th, along the eastern edge of a strong oceanic anticyclone. In higher latitudes a northwesterly wind of force 7 was reported near the Aleutians southwest of Dutch Harbor on the 30th during the prevalence of the deepest cyclone of the month in northern waters. Thus, although extratropical LOWS were fairly numerous over the Aleutians and the Gulf of Alaska, and farther westward to Japan, they were unusually mild in character.

Tropical cyclones and gales.—Several cyclonic disturbances occurred in the Far East during July, but only one of them, so far as our reports indicate, was a typhoon having winds of hurricane force. This storm appears on our charts as a LOW east of the Philippines on the 7th. It moved northward and its center lay west of Kiushiu Island on the 9th. On that date the British steamer *Lacklan*, east-bound from Shanghai, passed through the storm center, with light variable winds, lowest barometer 968.8 millibars (28.61 inches), in 32°30′ N., 125°25′ E., at 1 p. m. Before the passage of the center the highest wind on ship was of force 12 from the northeast, and after the passage of the center the highest wind was of force 10 from the south. According to a press report from Tokio, considerable damage was done by the storm in the Oshima Islands, with one person reported killed and 19 missing. Some 900 dwellings were reported partly or wholly destroyed.

Another tropical cyclone, of as yet unknown intensity, occurred on the 18th between Taiwan and the Nansei Islands. The only gale report at hand concerning it was received from the British motorship *Silveray*. This ship encountered violent squalls of force 8–9. Her lowest barometer was 996.3 millibars (29.42 inches) in 24°38′ N., 129°54′ E.

A third disturbance occurred between Taiwan and Japan during the 22d to 24th. The intensity of the disturbance is gathered only from the report of the Nor-

wegian motorship *Evita*, which met an east gale of force 8, lowest barometer 1,005.1 millibars (29.68 inches), in 25°01′ N., 128°28′ E.

A full report on the typhoons and depressions of the Far East from the Weather Bureau, Manila, P. I., follows below.

Two small disturbances occurred in the southeastern Pacific Tropics. In the first, on the 19th, the Norwegian motorship *Thor 1*, in 17°30′ N., 118°40′ W., experienced a wind no higher than force 7, from north-northeast, but there was a wind shift from northeast to south as the ship crossed the LOW, with lowest observed barometer of 1,000.7 millibars (29.55 inches).

In the second, on the 29th, the American steamer *Susan V. Luckenbach* encountered a strong east gale at noon, lowest barometer 1,009. 8 millibars (29.82 inches), close in off the Mexican coast about midway between Acapulco and Manzanillo. At evening observation of the 29th a radio message from the Italian steamer *Leme*, up the coast near Manzanillo, reported a north-northeast gale of force 9, barometer 1,000 millibars (29.53 inches), as the disturbance went inland.

Fog.—Fog had increased greatly over nearly all northern and upper middle waters of the North Pacific since the previous June. The fog belt in open ocean extended between about longitude 138° W. nearly to the Japanese coast. In west longitudes its southern limit was close to the 40th parallel, but in east longitudes the southern boundary was close to 35° N. Along the northern routes there was some 20 to 35 percent or more of fog between longitudes 150° W. and 145° E., with the most frequent occurrences as a rule about midway between the western Aleutians and central Japan. Along the American coast fog was abnormally frequent off California, where it was reported on 24 days. There were 8 days with fog off Lower California, and 11 off Washington, mostly in or at the entrance to the Strait of Juan de Fuca. Two days were observed with fog near the Mexican coast south of the Gulf of California.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST JULY 1939

By BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Typhoon, July 7–12, 1939 (Northern).—This disturbance probably originated over the regions west-southwest of the Bonin Islands and first affected the Nansei (Loochoo) Islands during the afternoon of July 7, at that time being central about 400 miles east of Naha. The storm moved in a northwesterly direction, passing close to and southwest of Oshima, into the Eastern Sea. A change to the north over the Yellow Sea brought the center to the northern part of Chosen (Korea) where it recurved to the northeast and east as it moved toward the Pacific Ocean. The 2 p. m. observation, July 8, from Oshima showed a northeast wind, force 8 blowing, with a pressure value of 733.5 mm. (978.0 mb.). Naha, at the same time, had north-northwest winds, force 4, with 751.0 mm. (1,001.3 mb.) and Borodino Island reported south-southwest winds, force 4, and 752.7 mm. (1,003.5 mb.) for pressure.

Typhoon, July 7–13, 1939 (Southern).—This typhoon first appeared as a disturbance secondary to the typhoon described above and intensified when the primary storm had moved across the Eastern Sea. As a depression, central about 350 miles east-northeast of San Bernardino Strait at 6 a. m., July 7, it moved a short distance to the west-northwest, then northwest and inclined to the north. It intensified to typhoon strength when east of Balintang Channel and then moved north-northeast for a short distance. The morning weather map of July 10 had the center located about 300 miles east-southeast of Ishigakijima from which position it began a rapid northwesterly motion. The center crossed the Eastern Sea during July 11 and was entering the coast between Gutzlaff and Kamen during the morning of the next day. It passed close to and southwest of Shanghai during the late forenoon and early afternoon (July 12) and continued along a course almost parallel to the coast line. It disappeared over the continent the next day.

Pressure values and wind observations received from Shanghai on July 12 are as follows: At 6 a. m. pressure was 747.4 mm. (996.4 mb.) with northeast winds, force 7. At 2 p. m. the barometers recorded 744.4 mm. (992.4 mb.) with east-northeast winds, force 12. Newspapers printed dispatches in which it was stated that the winds reached velocities as high as 80 miles per hour and that at least six persons were killed in Shanghai because of this storm.

Typhoon, July 10–17, 1939.—Forming rather quickly about 120 miles west of northern Luzon, this typhoon moved northwest and changed its direction to the northeast after about one day's progress away from the Philippines. It moved across the western part of the Balintang and Bashi Channels to the ocean regions east of Formosa, where it inclined to the north, then northwest, thus crossing northern Formosa and the Formosa Channel and passing into the continent. It disappeared about 500 miles away from the coast line after moving northwest and west.

The afternoon situation west of northern Luzon, July 10, indicated the formation of a new disturbance. The S. S. *Mausang*, en route to Hong Kong, reported from various positions about 180 miles west of Baguio pressure values between 749 and 748 mm. (998.6 and 997.3 mb.), with winds of force 6 from the north-northwest and west. The S. S. *Tjikarang*, at 2 p. m. Manila time, had winds of force 5 from the north-northwest with pressure at 749.0 mm. (998.6 mb.), the ship's position being latitude 18.7° N, longitude 116.6 E. Vigan and Laoag, situated along the western coast of Luzon, had southwest and south winds, force 3, with pressure at 749.5 mm. (999.3 mb.).

It seems that the north quadrant winds due to the typhoon preceding this storm interacted with the strong southwesterly current to form this typhoon. The pilot balloon observation at Aparri on the afternoon of the 10th had northwest winds at some levels which could be caused by the typhoon center 550 miles northeast of the station.

Typhoon, July 15–20, 1939.—As a low-pressure area, then depression, this disturbance moved in a northwesterly direction from the ocean regions about halfway between the Philippines and the Mariana Islands. The morning of the 18th found the storm intense enough to be classified as a typhoon, central about 400 miles northeast of Aparri, Cagayan Pr. For a few hours it moved north-northeast, then changed to the northwest when directly east of southern Formosa. The storm entered the continent July 20 about 120 miles south of Shanghai and disappeared the next day.

The morning observations, July 19, from Ishigakijima, Nansei Islands, showed a pressure of 748.0 mm. (997.3 mb.) with calm. At Naha, Nansei Islands, southeast winds, force 3, were reported, with pressure at 749.5 mm. (999.3 mb.).

Typhoon, July 20–27, 1939.—Similar to the typhoon just described, a depression formed over the ocean regions between the Philippines and the Mariana Islands and then moved northwest to a position about 250 miles east-by-north of Basco, Batanes Islands, where it was stationary

for 2 days. It intensified into a typhoon and moved rapidly north-northeast to the regions about 100 miles northeast of Oshima, Nansei Islands, where it sharply changed to the west. It almost crossed the Eastern Sea, July 26 and 27, but disappeared before it reached the coast.

On July 24 the morning observations at Naha and Borodino, Nansei Islands, were the lowest pressures reported during the progress of this storm. Naha had 749.5 mm. (999.3 mb.) with northeast winds, force 3. Borodino reported 751.3 mm. (1,001.7 mb.) with south winds, force 4. As the typhoon changed its course to the west on the morning of the 25th, Oshima recorded a pressure value of 751.0 mm. (1,001.3 mb.), with northwest winds of force 1.

Typhoon, July 22–25, 1939 (Pacific Ocean).—A well-developed typhoon appeared about 700 miles east of Formosa, moved rapidly north, then northwest, passing close-to and south of Kiu-siu Island, Japan. It crossed the northern part of the Eastern Sea and then traversed the Yellow Sea, disappearing over the continent west of Shantung Peninsula.

Observations made at Borodino Island and other stations show the strength of this storm. At 6 a. m., July 22, Borodino pressure was 748.6 mm. (998.0 mb.), with winds from the north-northeast, force 4. The afternoon pressure (2 p. m.) was 747.0 mm. (995.9 mb.), with winds of force 3 from the north-northeast. On the 23d, as the center passed from the Pacific Ocean into the Eastern Sea, Oshima, Nansei Islands, and Kagoshima and Nagasaki, both on Kiu-siu Island, had pressure values between 748.0 mm. and 750.0 mm. (997.3 and 1,000.0 mb.), with winds not exceeding force 4.

Typhoon, July 22–24, 1939 (Formosa Channel).—During these days, there was evidence from ships that a small but active center existed over the southern part of the Formosa Channel. This center formed close-to and west of southern Formosa, moved northwest about 30 miles, then northeast about 60 miles, after which no trace of it could be found.

The U. S. S. *Gold Star*, en route Hong Kong to Shanghai and the U. S. S. *Henderson*, en route Shanghai to Hong Kong, passed each other along the coast about the middle of the Formosa Channel. Both ships reported winds from the northeast quadrant, force 5 to 7, with pressure values between 746.3 mm. and 748.0 mm. (994.9 and 997.3 mb.).

It must be kept in mind that no weather observations were received from Formosa during this whole period and that the positions and directions of these disturbances, when near or over Formosa, may be subject to correction when information from Formosa during these days becomes available.

The upper winds, as received by radio broadcasts mostly, show the gradual movement of the southwesterly current toward the Pacific Ocean, its extent, and its strength. Beginning July 3, this current, which had been in existence over Thailand (Siam) and Sumatra during June, advanced eastward. It passed Menado on July 5, and reached the regions east of Yap the same day. Not until July 21, however, did Guam have the southwest winds. Over the Philippines, the southwest winds passed Zamboanga July 3, Cebu on July 5, and Manila on July 7 and 8. A day later Aparri was under its influence. Then, for the rest of the month, the whole Archipelago was under the influence of this powerful current, the velocities often reaching 80 k. p. h. Zamboanga, however, escaped the strength of this current of air, the directions being from the southwest quadrant, but much weaker than the northern stations, and with east quadrant winds appearing once in a while aloft. The forecasting value of the pilots consisted in the persistence of the high velocities. A disturbance would be moving away from the Archipelago, but the velocities aloft would maintain their high values, which was a good indication that a new disturbance was forming. Hong Kong and the stations of northern Indochina did not feel the strength of the southwest current of air until about July 18, after which the velocities reported compared with those of the Philippines. The only pilots from northern stations were those from the U. S. S. *Augusta* and the U. S. S. *Blackhawk*, the former ship being first at Tsingtao and then at Shanghai, the latter ship remaining at Cheefoo during the whole period. The U. S. S. *Augusta* reported southeast, south, and southwest quadrant winds mostly, with one ascent at Shanghai showing northeast quadrant winds below and southeast quadrant winds aloft. Velocities were never above 50 k. p. h. The U. S. S. *Henderson* was en route from Shanghai to Hong Kong July 22 and 23 and reported northeast quadrant winds from 20 to 60 k. p. h. from positions in the Eastern Sea along the China coast line north of Formosa while the typhoon of July 22 to 24 was in existence over the southern part of the Formosa Channel. In conclusion, the data available indicate that the southwest current of air was the most active sector of the typhoon circulation and its extent was from Hong Kong and northern Indochina southward to southern Sumatra and other islands having the same latitude, Zamboanga and other stations to the south, however, being without the strong velocities of the northern stations. No information west of Thailand (Siam) is available at the present writing.

The Manila newspapers of July 25 reported that two persons were killed and considerable damage to public and private property resulted from the heavy rains caused by the above series of typhoons.

Typhoon, July 25–August 6, 1939.—From a low pressure area over the Pacific, first manifesting itself on the afternoon of July 25, and moving northwesterly, a typhoon developed July 27, being central about 450 miles east-northeast of Aparri. Moving northwesterly about 180 miles, then westerly about 250 miles, it inclined northward, thus approaching the coast line of northern Formosa. It then executed a counterclockwise loop southward over Formosa, as well as can be determined from observations available, and began to move along an easterly course, being located about 250 miles from central Formosa on the morning of August 1. It then moved rapidly east-northeast or northeast to a position about 200 miles east of Oshima, Nansei (Loochoo) Islands where it was stationary August 3 and 4. It then moved about 100 miles to the northwest and suddenly changed to the east, as a weak disturbance which soon disappeared over the ocean regions between the Bonins and Japan.

Pressure values reported from Ishigakijima, Nansei (Loochoo) Islands, on July 30 and 31 were between 748 and 749 mm. (997.3 and 998.6 mb.) with northeast quadrant winds, force 3 and 2. At the same time, pressure values over the whole Philippine Archipelago fell suddenly, the greatest fall being at Basco, where 746.7 mm. (995.5 mb.) was the lowest value reported for the weather maps (July 31, 2 p. m.) with west-southwest winds force 5. Because of this sudden fall of pressure, so far-reaching in effect, it is thought that the typhoon center made a loop to the south. Besides, at Aparri, the upper winds of the afternoon ascents of July 29 and 30 reached values of 110 k. p. h., the directions being southwest and west-southwest.

Typhoon, July 28–August 8, 1939.—Before July 28, a low pressure area existed over the ocean regions adjacent to the northern Mariana Islands as a disturbance which

seemed to have formed southeast of that locality. It was moving northwest and developed into a typhoon on the morning of July 28, central about 250 miles south or south-southeast of the Bonins. This typhoon moved westerly for about 700 miles and then made a short but rather sharp inclination to the north, being located near latitude 24° N., longitude 131° E., on the morning of July 31. Then it began its rapid movement toward the east-northeast, passing near or over the Bonins early in the morning of August 2. From the few observations available, it seems that it was stationary about 400 miles east-northeast of the Bonins on August 3 and 4, after which it moved north, then northwest, the latter course directing the center toward Japan. It crossed central Japan on August 6, and then recurved to the northeast over the Sea of Japan. An inclination to the east caused the center, now weakening, to cross Hokkaido Island on its way to the Pacific Ocean.

Pressure at Borodino Island, July 31, 6 a. m., was 745.6 mm. (994.1 mb.) with winds of force 4 from the northeast. At the Bonins, August 2, 6 a. m., a pressure value of 743.0 mm. (990.6 mb.) was reported, the winds being north, force 5. The S. S. *Manoeran*, August 4, added to the afternoon weather telegram the following remark: "In center of typhoon. 0530 G. M. T. 30° N., 149° E., pressure 720 mm., moving north" (959.9 mb.). At 0600 G. M. T., the weather observation from this ship, latitude 30.0° N., longitude 149.1° E., showed pressure at 720.5 mm. (28.366 in.) with west-northwest winds, force 10.

The upper winds over the Philippines remained approximately the same as those predominating during the typhoons of the earlier days of the month. Heavy rains caused the death of three persons in the Philippines during the latter part of the month.

At Vigan, Ilocos Sur, during the forenoon hours of July 29, a strong whirlwind, about 90 meters in diameter, formed near the sea shore and moved inland about a distance of 4 kilometers. It was mild when in process of formation, but became violent when passing over the center of Vigan, where it ripped up roofs and uprooted trees. The whirlwind passed close to the building where the meteorological instruments were installed. The anemograph registered 40 m. p. h. as its highest velocity and the barometer fell about 4 mm. and then ascended to its former value as the storm went by. There was a counterclockwise rotation, with strong upward winds. Considerable destruction to substantial buildings resulted, and one person was injured to such an extent that death resulted a few days later.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, July 1939*

[For description of tables and charts, see REVIEW, January, p. 31]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	80.9	+0.6	Tuskegee	105	19	Scottsboro	58	1 12	4.82	−0.54	Spring Hill	13.12	Anniston	1.18
Arizona	81.2	+1.1	2 stations	120	1 13	Alpine	33	1 11	1.14	−1.07	Nogales	5.58	Marinette	.00
Arkansas	82.0	+1.5	do	110	22	2 stations	55	1 30	3.34	−.45	El Dorado	9.67	Gravette	.34
California	72.9	−.7	Greenland Ranch	123	1 13	Twin Lakes	26	6	.08	+.01	Needles	1.88	63 stations	T
Colorado	69.7	+2.5	Sedgwick	112	11	Pearl	18	22	.90	−1.28	Lake Moraine	2.63	2 stations	T
Florida	81.3	.0	2 stations	100	1 29	Bushnell	63	26	7.59	+.35	Moore Haven	16.13	Fernandina	1.40
Georgia	80.5	+.4	5 stations	105	1 19	Blairsville	50	1 16	4.83	−.92	Warrenton	11.12	Resaca	1.66
Idaho	68.8	+.7	Lewiston	117	27	Obsidian (near)	21	17	.69	+.01	Atlanta	2.72	2 stations	.07
Illinois	76.7	+.2	2 stations	104	1 8	Marengo	48	16	3.39	+.11	Edwardsville	7.55	Springfield	1.07
Indiana	75.2	−.5	Shoals	103	28	Wheatfield	40	16	4.19	+.82	Veedersburg	8.38	Winamac	1.62
Iowa	76.2	+1.6	Logan	113	12	Sibley	48	29	3.15	−.51	Cedar Rapids	8.63	Forest City	.74
Kansas	83.4	+4.3	Burlington	116	21	Wellington	55	30	1.40	−1.76	Florence	3.86	Lyndon	.17
Kentucky	76.5	−.6	Bowling Green	102	13	5 stations	50	12	4.83	+.64	Valley View	9.92	Princeton	.85
Louisiana	82.7	+.9	Plain Dealing	108	15	2 stations	62	1 17	5.97	−.17	Abbeville	12.10	Minden	1.59
Maryland-Delaware	73.9	−1.4	Cumberland, Md	97	8	do	39	16	3.32	−.90	Princess Anne, Md	9.84	Wilmington, Del	1.23
Michigan	69.9	+1.5	2 stations	99	27	4 stations	32	1 15	1.65	−1.27	Calumet	4.53	Cheboygan	.32
Minnesota	71.7	+1.6	Pipestone	106	12	2 stations	35	1	2.37	−.90	Worthington	6.35	Park Rapids	.20
Mississippi	82.0	+.9	Jackson	104	15	Batesville	58	31	4.61	−.41	Biloxi	13.25	Clarksdale	.74
Missouri	80.0	+2.0	2 stations	107	1 13	4 stations	51	1 29	2.91	−.76	Farmington	9.38	Edgerton	.26
Montana	69.2	+2.1	3 stations	108	1 10	Conway's Ranch	23	21	.68	−.71	Plevna (near)	3.65	Campbell Farm Camp No. 4.	T
Nebraska	80.2	+4.7	2 stations	116	1 11	Hyannis	46	22	1.83	−1.31	Wahoo	6.80	2 stations	.29
Nevada	74.0	+1.5	Overton	119	1 13	San Jacinto	34	16	.60	+.21	Charleston Ranger Station.	3.36	do	.00
New England	69.3	+.2	Manchester, N. H	100	4	2 stations	35	1 3	2.27	−1.46	Fort Kent, Maine	10.51	Concord, Mass	.28
New Jersey	73.4	−.3	2 stations	98	1 8	Charlotteburg	38	23	2.33	−2.46	2 stations	5.65	Long Branch	.70
New Mexico	72.5	+.2	do	106	1 5	Elizabethtown	27	13	2.45	−.07	Palma	7.45	Gage	T
New York	70.1	+.4	Port Jervis	99	25	3 stations	37	1 3	2.36	−1.53	Olean	6.92	Mineola	.39
North Carolina	76.3	−.6	2 stations	102	19	Banners Elk	40	16	7.67	+1.76	Swansboro	15.87	Nantahalo	3.75
North Dakota	72.6	+3.7	Turtle Lake	108	29	2 stations	37	1	1.81	−.62	Ryder	5.87	Fargo	.42
Ohio	72.9	−.8	3 stations	98	1 7	do	42	1 11	4.15	+.32	Lock No. 14	8.78	Wooster No. 2	1.52
Oklahoma	84.3	+2.5	Alva	115	21	Goodwell	52	10	1.65	−1.18	McAlester	5.07	Tipton	.00
Oregon	67.6	+1.1	Umatilla	117	27	Wallowa	22	17	.49	+.08	Seaside	2.50	Hood River Experiment Station.	T
Pennsylvania	71.7	−.5	Ephrata	100	25	3 stations	36	1 16	3.12	−1.15	Smethport	8.23	Paupack	.49
South Carolina	80.2	+.2	Little Mountain	106	19	Longcreek (near)	54	15	6.10	+.26	Camden	13.36	Mars Bluff Bridge	2.18
South Dakota	77.5	+4.4	Wood	115	11	Camp Crook	42	22	1.85	−.59	Clear Lake	7.18	Pollock	.40
Tennessee	78.4	+.7	2 stations	103	1 7	Rugby	49	1 12	3.82	−.66	Bolivar	9.45	Cookeville	1.13
Texas	84.4	+1.4	do	114	1 8	Muleshoe	51	11	2.60	−.03	Angleton	15.50	Stamford	.00
Utah	72.4	+.7	3 stations	112	1 12	Woodruff	28	21	.54	−.38	Standrod	2.31	Moab	.00
Virginia	74.1	−1.3	Columbia	99	14	2 stations	40	1 15	6.24	+1.65	Diamond Springs	13.38	Washington, D. C	2.01
Washington	67.0	+.9	4 stations	115	27	do	29	1 12	.85	+.20	Sedro-Wooley	5.00	6 stations	.00
West Virginia	72.1	−1.1	Hinton	99	13	Bayard	33	16	5.81	+1.20	Williamson	11.09	Wellsburg	3.32
Wisconsin	71.6	+1.4	Wisconsin Dells	102	6	Laona	32	16	2.06	−1.45	Ladysmith	6.86	Sheboygan	.30
Wyoming	67.7	+2.0	2 stations	110	1 10	Gallatin	22	21	.81	−.53	2 stations	2.43	2 stations	.06
Alaska (June)	53.1	+.7	do	87	1 11	Little Diomede Island.	10	1	1.79	+.07	Bell Island	4.89	Pilgrim Springs	.11
Hawaii	73.8	−.6	Mana (Kauai)	91	31	Kanalohuluhulu	46	6	6.54	+.63	Kukui	32.00	4 stations	.00
Puerto Rico	78.7	+.1	Juana Diaz	96	21	Guineo Reservoir	57	1 29	5.07	−1.20	Maricao	18.94	Coamo (near)	.31

1 Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1939*

[Compiled by Annie E. Small by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*9–10*	*In.*	*In.*
New England							**69.4**	**+0.5**										**78**	**2.15**	**−1.3**											**5.3**		
Eastport	75	67	85	29.86	29.94	+0.01	60.8	+0.4	85	25	70	47	23	52	32	57	55	87	4.01	+0.9	9	7.9	s.	22	s.	1	9	12	10	5.8	0.0	0.0
Greenville, Maine	1,009	4	41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.0	.0
Portland, Maine	103	82	117	29.84	29.96	+.01	67.9	−.2	88	7	76	51	3	60	.....	.....	.....	77	5.94	+2.7	6	7.3	s.	25	nw.	1	11	16	4	.....	.0	.0
Concord	288	54	72	29.66	29.96	.00	70.8	+2.3	95	7	83	46	13	58	40	.....	.....	.....	1.41	−2.2	9	5.2	se.	24	nw.	8	12	16	3	4.5	.0	.0
Burlington	403	11	48	29.50	29.93	−.01	69.6	−.7	94	26	79	46	13	60	32	63	59	72	2.83	−.7	10	7.2	s.	26	s.	14	9	11	11	5.4	.0	.0
Northfield	876	12	60	29.03	29.96	+.02	66.4	+.5	91	7	79	40	13	54	39	61	59	78	1.57	−2.0	13	5.9	sw.	24	sw.	5	7	14	10	5.7	.0	.0
Boston [1]	29	33	62	.....	29.95	−.01	72.3	+.6	93	8	81	56	3	64	27	63	.....	68	.75	−2.7	4	9.7	w.	25	w.	31	2	21	8	6.3	.0	.0
Nantucket	12	14	90	29.96	29.98	.00	68.2	+.4	80	29	74	54	22	62	18	64	63	89	2.29	−.6	9	13.2	sw.	35	ne.	23	9	10	12	6.9	.0	.0
Block Island	26	11	46	29.95	29.98	+.01	68.8	+.4	82	31	75	56	3	63	17	65	63	86	.47	−2.6	8	12.7	sw.	42	w.	10	17	12	2	3.2	.0	.0
Providence [2]	159	215	251	29.91	29.98	+.01	72.8	−.6	92	10	82	54	20	63	28	66	63	75	1.07	−2.2	8	10.0	nw.	38	nw.	10	12	12	7	4.7	.0	.0
Hartford [2]	159	66	100	29.91	29.95	−.02	73.1	+1.5	93	8	83	53	3	63	32	65	62	74	2.80	−1.6	12	7.4	s.	30	nw.	10	6	14	11	6.3	.0	.0
New Haven [2]	106	74	153	29.96	29.98	+.01	73.0	+1.2	91	8	82	55	3	64	28	66	62	72	.52	−3.8	8	8.2	s.	22	s.	8	9	19	3	5.1	.0	.0
Middle Atlantic States							**74.5**	**−0.4**										**72**	**3.42**	**−0.9**										**5.8**		
Albany [1]	292	26	40	29.64	29.95	−.01	71.8	−.8	97	25	84	45	13	60	40	64	57	59	2.86	−.6	10	7.9	s.	24	nw.	2	6	15	10	6.0	.0	.0
Binghamton	871	57	79	29.06	29.97	.00	71.6	+1.6	95	26	84	44	3	60	41	62	58	64	1.24	−2.5	11	5.9	ne.	18	nw.	12	5	14	12	6.4	.0	.0
New York	314	415	454	29.63	29.96	−.02	74.1	+.3	90	25	81	58	23	67	27	66	61	70	.44	−3.8	6	12.1	s.	30	nw.	12	7	13	11	5.6	.0	.0
Harrisburg [1]	351	30	49	29.60	29.98	.00	75.2	+.4	96	25	86	51	3	64	37	66	61	66	1.63	−2.2	9	7.6	se.	31	s.	14	7	12	12	6.0	.0	.0
Philadelphia	114	174	367	29.85	29.97	−.01	76.2	.0	94	25	84	60	23	68	25	67	63	68	2.19	−2.0	10	11.0	sw.	35	s.	14	10	13	8	5.3	.0	.0
Reading	323	283	306	29.63	29.97	.....	74.2	−1.3	95	25	83	55	3	65	28	62	61	67	3.43	−.8	8	9.7	nw.	31	ne.	26	9	12	10	5.2	.0	.0
Scranton	805	72	104	29.12	29.97	−.01	72.8	+1.1	94	25	84	47	3	62	38	62	56	60	.58	−3.4	9	5.9	n.	25	nw.	8	7	19	5	5.1	.0	.0
Atlantic City	52	57	172	29.92	29.97	−.01	72.5	+.4	88	31	79	57	23	66	26	67	64	78	1.60	−2.3	5	14.1	s.	47	sw.	14	10	10	11	5.3	.0	.0
Sandy Hook	22	10	57	29.94	29.97	.....	74.0	+.5	91	8	80	60	23	68	24	67	64	77	.91	−4.2	6	10.9	s.	39	w.	10	10	8	13	5.4	.0	.0
Trenton	190	89	107	29.77	29.96	.....	74.6	+.1	95	25	84	55	23	66	31	66	62	69	1.04	−2.9	6	7.5	s.	32	nw.	10	9	11	11	5.8	.0	.0
Baltimore [2]	123	100	215	29.96	29.98	.00	77.2	.0	93	8	85	62	16	70	24	69	65	72	2.41	−2.2	12	9.4	s.	36	sw.	4	11	8	12	5.5	.0	.0
Washington	112	62	85	29.86	29.98	−.02	76.2	−.6	93	8	84	58	17	68	25	68	65	73	2.01	−2.7	15	5.7	nw.	23	nw.	10	7	15	9	5.8	.0	.0
Cape Henry	18	8	54	29.96	29.98	.....	75.8	−1.7	91	30	82	62	16	70	20	70	68	81	9.36	+4.0	12	9.5	sw.	47	nw.	18	6	16	9	5.7	.0	.0
Lynchburg	686	144	184	29.28	30.00	−.01	75.6	−1.9	93	24	85	59	21	66	27	68	65	76	6.05	+1.8	16	6.1	nw.	27	n.	26	8	9	14	6.3	.0	.0
Norfolk	91	80	125	29.90	29.99	−.01	77.3	−1.4	93	24	85	63	21	70	25	70	67	77	12.40	+6.6	16	8.2	sw.	41	nw.	10	5	10	16	6.7	.0	.0
Richmond [2]	144	11	52	29.81	29.98	−.03	76.2	−2.3	94	24	85	60	21	68	25	70	68	84	4.33	−.4	12	6.7	sw.	32	n.	10	9	12	10	5.7	.0	.0
Wytheville	2,304	49	55	27.67	30.02	+.01	71.2	−1.4	88	8	81	50	12	61	34	64	62	80	5.57	+1.6	16	5.1	w.	21	nw.	18	5	13	13	6.4	.0	.0
South Atlantic States							**79.9**	**+0.8**										**79**	**6.99**	**+1.2**										**5.6**		
Asheville	2,253	89	104	27.74	30.01	−.01	74.3	+2.6	95	18	86	54	17	63	36	66	64	79	3.79	−.5	16	6.1	nw.	24	s.	20	6	14	11	6.0	.0	.0
Charlotte [2]	779	63	86	29.19	29.99	−.03	79.4	+1.0	98	19	89	63	22	70	28	71	68	79	8.07	+3.0	14	6.6	sw.	24	s.	20	4	17	10	6.4	.0	.0
Greensboro [1]	886	6	56	29.08	30.00	.....	76.7	.....	94	14	86	60	15	67	28	69	67	79	4.18	.....	15	7.0	sw.	25	n.	10	4	15	12	6.2	.0	.0
Hatteras	11	5	50	29.99	30.00	−.01	78.0	−.2	87	30	83	66	16	73	16	73	71	81	5.84	+.4	16	10.9	sw.	49	nw.	14	10	12	9	5.0	.0	.0
Raleigh [2]	376	103	146	29.62	29.99	−.03	77.6	−1.2	93	27	87	63	22	68	24	72	69	81	8.31	+2.9	13	7.3	sw.	32	n.	18	6	15	10	6.0	.0	.0
Wilmington	72	73	107	29.93	30.00	−.01	79.2	+.1	92	28	86	66	12	72	21	73	71	80	7.43	+.3	15	8.8	sw.	28	s.	21	8	14	9	5.3	.0	.0
Charleston [2]	48	11	92	29.95	30.00	−.03	81.8	+.4	94	28	88	69	28	75	25	74	73	88	10.77	+3.9	13	9.6	s.	37	ne.	19	8	15	8	5.3	.0	.0
Columbia, S. C.	347	70	91	29.63	30.00	−.02	81.5	+.6	102	19	91	67	22	72	26	72	69	74	6.93	+1.6	13	7.5	s.	27	nw.	20	8	22	1	4.8	.0	.0
Greenville, S. C.	1,040	70	78	28.91	29.98	.....	79.5	+2.6	100	19	90	62	22	69	29	70	66	71	5.70	+.3	11	6.1	sw.	38	sw.	20	6	14	11	6.0	.0	.0
Augusta [2]	182	62	77	29.54	29.98	−.04	82.6	+1.3	102	19	93	67	25	72	31	72	68	73	6.82	+1.4	9	5.6	s.	27	nw.	25	9	14	8	5.5	.0	.0
Savannah [2]	65	73	152	29.95	30.00	−.03	82.8	+1.3	97	19	92	71	10	74	22	75	73	81	5.50	−1.1	14	9.6	sw.	30	nw.	21	6	19	6	5.5	.0	.0
Jacksonville	43	86	110	29.98	30.02	−.01	82.2	+.1	95	16	91	70	21	73	22	74	72	81	7.71	+1.0	17	6.7	sw.	29	w.	10	5	22	4	5.7	.0	.0
Florida Peninsula							**82.4**	**+0.5**										**77**	**7.54**	**+2.0**										**5.5**		
Key West [2]	21	10	64	29.99	30.00	−.03	83.6	+.1	91	16	89	71	12	78	18	77	75	76	3.15	−.1	8	8.3	se.	33	nw.	12	10	13	8	5.4	.0	.0
Miami	25	124	168	30.02	30.06	+.02	82.0	+1.0	92	15	88	71	1	76	18	75	73	78	10.25	+4.8	14	7.5	se.	23	sw.	4	10	10	11	5.9	.0	.0
Tampa [2]	35	88	197	30.02	30.03	−.01	81.6	+.4	93	24	89	69	12	74	20	.....	.....	.....	9.21	+1.3	13	8.6	s.	30	s.	7	6	23	2	5.3	.0	.0
East Gulf States							**81.5**	**+0.9**										**79**	**4.55**	**−1.1**										**5.8**		
Atlanta [1]	976	5	72	28.99	29.98	−.04	80.2	+2.1	101	19	91	64	15	69	29	71	68	75	3.35	−1.3	11	7.0	nw.	30	nw.	4	6	12	13	6.1	.0	.0
Macon [2]	370	79	87	29.50	29.99	−.03	81.4	+.2	100	19	92	66	15	71	29	75	69	...	6.04	+1.3	11	5.9	s.	22	n.	6	4	20	7	6.2	.0	.0
Thomasville	273	49	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Apalachicola	35	11	51	29.97	30.01	.....	81.6	−.1	95	16	88	68	14	75	26	76	74	79	5.66	−2.1	18	6.8	w.	37	ne.	6	3	15	13	6.9	.0	.0
Pensacola	56	149	185	29.95	30.01	.00	80.8	−.2	95	15	87	70	16	75	23	75	73	79	7.10	+.3	18	10.5	nw.	48	nw.	16	6	19	6	5.6	.0	.0
Anniston	741	9	.....	.....	.....	.....	79.6	+1.7	99	14	91	61	13	68	31	.....	.....	.....	1.18	−4.0	13	.....	nw.	.....	.....	.....	7	21	3	.....	.0	.0
Birmingham [2]	700	11	48	29.35	29.99	−.02	80.7	+.5	99	14	90	67	1	71	27	72	69	77	3.39	−1.8	14	5.1	nw.	24	se.	19	9	16	6	5.2	.0	.0
Mobile	57	86	161	29.94	30.00	−.01	82.0	+.6	98	15	90	67	21	74	23	75	73	81	7.02	+.1	15	7.7	s.	37	n.	16	5	18	8	5.8	.0	.0
Montgomery [2]	218	92	105	29.75	30.00	−.02	82.4	+.7	99	19	92	70	22	73	27	73	71	79	4.18	−.7	13	5.8	w.	21	nw.	29	7	16	8	5.4	.0	.0
Meridian [2]	376	67	92	29.68	30.00	−.02	82.1	+1.7	99	15	92	69	28	72	29	75	73	...	4.29	−.6	10	5.0	sw.	24	n.	7	3	22	6	5.7	.0	.0
Vicksburg	247	82	102	29.73	29.98	−.02	82.5	+1.2	100	15	92	66	20	73	29	75	72	78	3.65	−.9	8	6.9	sw.	29	n.	27	10	11	10	5.6	.0	.0
New Orleans [2]	53	76	84	29.97	30.00	.00	83.6	+1.2	99	15	91	71	29	76	20	76	74	82	4.21	−2.2	13	5.7	sw.	19	ne.	7	7	15	9	5.7	.0	.0
West Gulf States							**84.2**	**+1.6**										**72**	**3.39**	**+0.1**										**3.8**		
Shreveport [2]	249	92	227	29.78	29.97	−.01	86.0	+2.8	106	15	97	69	2	75	30	75	71	72	1.82	−1.7	11	10.0	sw.	46	nw.	20	11	17	3	4.5	.0	.0
Bentonville	1,303	12	51	28.59	29.92	−.05	80.7	+2.2	100	15	92	58	30	69	31	.....	.....	.....	.81	−3.5	6	5.9	sw.	18	w.	18	19	9	3	.....	.0	.0
Fort Smith	463	57	82	29.49	29.95	−.02	85.5	+4.0	104	21	97	69	30	74	31	72	67	61	.57	−2.8	6	6.4	e.	26	sw.	22	19	10	2	3.1	.0	.0
Little Rock [2]	357	94	102	29.69	29.96	−.03	82.4	+1.5	102	15	92	67	28	73	24	75	72	77	2.11	−1.4	5	7.6	sw.	36	sw.	2	20	5	6	3.5	.0	.0
Austin [2]	605	68	90	29.30	29.94	.....	85.1	+1.1	105	8	96	71	7	75	30	72	68	64	3.57	+1.2	5	8.5	s.	29	ne.	11	19	8	4	3.5	.0	.0
Brownsville [2]	57	88	96	29.91	29.93	.....	83.8	+.2	102	9	91	74	12	77	25	76	74	...	1.11	−.8	4	11.3	se.	28	se.	31	15	13	3	3.9	.0	.0
Corpus Christi [2]	20	11	78	29.90	29.95	−.01	84.0	+1.3	99	9	90	75	22	78	23	76	74	81	.75	−.8	4	12.9	s.	26	s.	3	19	8	4	3.5	.0	.0
Dallas [2]	512	220	227	29.42	29.93	.....	86.1	.....	103	8	96	68	2	76	28	73	67	60	1.11	−1.8	3	11.3	s.	39	ne.	9	19	7	5	3.0	.0	.0
Fort Worth [2]	679	92	110	29.21	29.93	−.03	86.6	+3.0	106	8	98	68	1	76	30	72	65	57	2.02	−.6	7	10.4	s.	32	w.	1	19	9	3	3.0	.0	.0
Galveston [2]	54	106	114	29.96	29.97	−.01	83.2	−.2	100	8	88	70	29	78	24	77	74	80	13.55	+9.8	9	10.6	s.	28	nw.	9	14	11	6	4.2	.0	.0
Houston [2]	138	157	190	29.91	29.97	.....	83.8	+.1	104	8	92	72	12	76	29	75	72	80	9.39	+5.4	5	9.5	s.	40	ne.	9	13	12	6	4.5	.0	.0
Palestine	510	64	72	.....	29.97	.00	83.7	+1.5	101	8	94	71	6	74	.....	.....	.....	68	.71	−2.0	9	7.5	s.	24	s.	26	14	13	4	.....	.0	.0
Port Arthur	34	59	134	29.94	29.98	.....	83.7	.....	100	8	90	71	21	77	24	76	74	77	7.88	+.9	6	11.6	sw.	37	e.	11	7	16	8	5.3	.0	.0
San Antonio [2]	603	111	301	29.34	29.93	−.02	85.2	+1.4	105	8	96	70	11	75	30	74	69	65	2.12	.0	3	12.8	se.	31	se.	17	14	13	4	4.0	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee							**76.4**	**−0.1**										**74**	**4.46**	**+0.7**										**5.8**		
Chattanooga [2]	762	71	214	29.27	29.99	−.03	80.6	+2.2	98	19	91	63	2	70	31	71	68	75	1.93	−2.3	11	6.8	w.	25	s.	19	8	12	11	5.5	0.0	0.0
Knoxville [2]	995	66	84	28.97	29.99	−.03	78.8	+1.7	96	19	89	61	17	68	31	70	67	74	8.37	+4.0	10	4.9	w.	17	ne.	8	10	15	6	4.6	.0	.0
Memphis [2]	399	78	86	29.67	29.96	−.04	81.8	+1.1	95	14	89	67	16	74	20	74	73	76	3.46	+.3	9	6.8	sw.	28	ne.	16	12	13	6	4.3	.0	.0
Nashville [2]	546	168	188	29.34	29.97	−.04	79.8	+.7	96	19	89	63	12	70	26	71	67	70	3.11	−.8	10	6.5	w.	31	sw.	26	8	15	8	5.1	.0	.0
Lexington	989	6					76.0	+.1	96	8	88	55	16	64	33				3.30	−.4	15		n.				15	10	6		.0	.0
Louisville [2]	525	106	120	29.40	29.98	−.02	77.9	−.7	95	18	87	62	11	69	24	69	63	75	5.91	+2.2	9	6.6	sw.	31	n.	8	10	14	7	5.0	.0	.0
Evansville	431	76	116	29.51	29.97	−.03	79.6	+.7	98	13	89	63	11	70	27	70	67	69	5.96	+2.5	11	6.9	n.	35	nw.	26	6	12	13	5.9	.0	.0
Indianapolis [2]	823	98	129	29.12	29.97	−.02	76.2	+.5	98	13	86	56	16	67	30	67	64	75	7.20	+3.9	12	6.5	sw.	29	nw.	28	9	9	13	5.9	.0	.0
Terre Haute	575	63	149	29.36	29.96		78.2		100	13	89	58	11	68	27	68	64	68	4.38	+1.2	11	7.3	se.	29	sw.	25	9	16	6	5.0	.0	.0
Cincinnati [2]	627	11	51	29.45	29.97	−.03	75.0	−.1	93	5	84	54	16	66	29	69	66	76	2.76	−.6	11	5.2	sw.	21	n.	8	7	10	14	6.3	.0	.0
Columbus [2]	822	90	110	29.11	29.97	−.03	74.6	−.3	95	7	84	56	11	65	27	66	63	74	2.55	−1.0	11	6.9	s.	37	sw.	8	8	10	13	7.8	.0	.0
Dayton	900	186	213	29.01	29.97		74.4	−1.0	94	13	84	55	16	65	29	66	62	70	4.17	+.9	14	7.1	sw.	29	sw.	25	8	11	12	6.1	.0	.0
Elkins [2]	1,947	65	83	27.95	30.02	+.01	69.0	−1.3	89	7	79	47	16	59	30	64	62	86	6.43	+1.0	17	4.5	se.	24	nw.	8	3	13	15	7.2	.0	.0
Parkersburg	637	77	84	29.31	29.98	−.03	74.2	−1.2	94	7	84	51	16	65	31	67	64	75	4.62	+.3	13	4.8	se.	23	nw.	8	6	16	9	5.8	.0	.0
Pittsburgh [1]	1,273	39	54	28.66	29.99	−.01	71.3	−3.3	93	7	81	53	11	61	32	64	61	73	2.73	−1.3	11	8.6	sw.	29	nw.	8	2	21	8	6.5	.0	.0
Lower Lake Region							**72.3**	**+0.9**										**67**	**2.69**	**−0.6**										**4.8**		
Buffalo [2]	768	243	280	29.22	29.96	−.01	70.5	+.7	91	7	78	50	15	64	27	63	57	65	1.51	−1.5	5	12.0	sw.	33	sw.	31	13	14	4	4.1	.0	.0
Canton	448	10	61	29.46	29.93		69.4	+.5	95	26	81	46	13	58	33	62	58	67	3.40	−.1	14	6.4	sw.	25	sw.	14	9	14	8	5.5	.0	.0
Ithaca	836	77	100	29.07	29.97		71.8	+1.3	97	7	84	47	3	60	39	63	58	64	3.17	−.4	10	7.6	nw.	22	s.	13	6	17	8	5.5	.0	.0
Oswego	335	71	85	29.58	29.94	−.02	70.8	+.4	91	7	79	55	18	63	27	64	59	67	1.14	−1.8	6	7.7	w.	20	nw.	14	12	10	9	4.9	.0	.0
Rochester [2]	523	86	102	29.38	29.96	−.01	72.2	+1.5	93	28	82	52	15	63	27	64	59	68	1.91	−1.0	8	7.5	sw.	18	w.	14	10	12	9	4.8	.0	.0
Syracuse [2]	596	65	79	29.50	29.93	−.04	72.6	+2.0	93	7	82	53	19	63	30	64	58	65	3.08	−.6	9	6.5	s.	19	nw.	2	9	13	9	5.5	.0	.0
Erie	714	57	81	29.22	29.96	−.02	72.0	+1.0	90	7	79	54	16	64	23	65	61	68	4.57	+1.6	9	6.8	sw.	23	nw.	13	12	14	5	4.4	.0	.0
Cleveland [2]	762	267	318	29.12	29.97	−.02	73.2	+1.8	92	7	81	57	16	66	22	65	60	67	1.53	−1.9	7	11.2	nw.	35	w.	8	15	9	7	4.1	.0	.0
Sandusky	629	5	67	29.28	29.95	−.04	74.0	+.6	96	13	83	55	11	65	30				5.06	+1.6	8	7.2	s.	24	nw.	4	10	11	10	5.1	.0	.0
Toledo [2]	628	79	87	29.30	29.98	−.01	73.5	+.3	95	13	83	52	15	64	26	65	61	72	2.16	−.9	9	8.4	w.	23	s.	23	20	7	4	3.5	.0	.0
Fort Wayne	857	69	84	29.07	29.98		73.8	−.7	96	13	83	55	16	64	27	65	60	66	2.18	−1.4	8	7.6	nw.	27	nw.	22	12	9	10	5.2	.0	.0
Detroit [1]	626	5	78	29.30	29.97	−.01	73.4	+1.3	96	13	84	51	15	63	29	65	60	64	2.54	−.8	8	8.3	s.	31	w.	8	12	12	7	5.1	.0	.0
Upper Lake Region							**70.2**	**+2.2**										**70**	**1.17**	**−2.0**										**4.1**		
Alpena	609	13	89	29.32	29.98	+.01	68.4	+2.5	90	31	78	47	15	59	31	62	58	70	.96	−1.8	5	9.7	nw.	40	nw.	9	18	11	2	3.2	.0	.0
Escanaba	612	41	49	29.32	29.98	+.01	68.8	+2.8	89	11	78	45	16	60	32	62	58	70	.38	−3.0	4	9.6	s.	31	n.	9	12	13	6	4.7	.0	.0
Grand Rapids [2]	707	70	244	29.23	29.96	−.02	74.2	+1.9	97	27	85	49	16	64	29	64	59		.46	−2.5	7	9.2	sw.	30	sw.	25	16	8	7	4.0	.0	.0
Lansing	878	5	90	29.05	29.97		71.2	+.3	93	27	82	46	16	60	30	64	60	69	1.60	−1.5	5	7.2	s.	19	nw.	28	14	11	6	4.5	.0	.0
Marquette	734	44	69	29.17	29.96	.00	67.4	+2.5	89	24	77	48	15	58	33				1.13	−2.0	7	7.0	nw.	24	s.	3	13	15	3	4.0	.0	.0
Sault Sainte Marie [1]	724	5	33	29.19	29.97	.00	64.5	+.7	93	6	77	41	2	52	36	59	55	73	1.08	−2.3	3	7.0	nw.	30	nw.	14	16	8	7	4.2	.0	.0
Chicago	673	7	131	29.26	29.97	−.01	74.0	+1.5	97	13	81	59	17	67	24	66	62	71	2.74	−.6	7	8.9	ne.	26	nw.	7	18	7	6	4.0	.0	.0
Green Bay	617	109	141	29.31	29.97	.00	73.2	+3.2	94	26	83	53	16	63	30	64	58	63	.79	−2.7	6	9.1	s.	30	nw.	6	13	9	9	4.7	.0	.0
Milwaukee [2]	681	97	221	29.24	29.98	+.01	73.2	+3.1	95	13	80	60	18	66	29	64	60	70	.51	−2.3	6	10.4	se.	28	e.	17	16	8	7	4.2	.0	.0
Duluth	1,133	5	47	28.75	29.94	−.01	67.0	+3.1	89	26	77	49	18	57	32	60	55	71	2.03	−1.7	6	9.9	ne.	42	w.	8	17	8	6	3.6	.0	.0
North Dakota							**73.4**	**+5.0**										**57**	**1.49**	**−1.1**										**3.6**		
Moorhead, Minn [2]	940	50	58	28.94	29.89	−.05	72.8	+4.7	102	12	85	48	1	61	37	63	57		.43	−3.0	7	7.7	s.	24	nw.	3	15	10	6	4.2	.0	.0
Bismarck [1]	1,677	8	57	28.17	29.89	−.04	74.4	+4.6	100	29	88	53	14	61	39	63	56	58	2.52	+.3	7	8.2	se.	27	n.	17	15	13	3	3.5	.0	.0
Devils Lake	1,478	11	44	28.35	29.89	−.04	72.6	+5.2	99	12	86	46	14	59	34	62	55	61	2.04	−.5	7	8.0	se.	26	nw.	12	13	13	5	4.2	.0	.0
Lemmon, S. Dak	2,602	4	38																											.0	.0
Grand Forks	832	11	71				72.4	+4.9	102	12	86	42	1	58	40	62	57		1.37	−1.4	9	7.5	se.									
Williston	1,878	42	50	27.93	29.85	−.07	74.6	+5.7	102	11	88	52	9	61	42	61	52	53	1.09	−.8	8	7.8	se.	35	nw.	11	20	11	0	2.5	.0	.0
Upper Mississippi Valley							**77.2**	**+2.1**										**68**	**2.74**	**−0.8**										**4.7**		
Minneapolis-St. Paul, Minn [1]	838	32	61	29.05	29.93	−.02	74.6	+2.3	95	6	85	56	1	64	32	65	61	65	2.75	−1.0	7	8.6	se.	26	nw.	13	15	7	9	4.5	.0	.0
Springfield, Minn	1,025	4	42				76.2		102	12	88	55	29	64	36	66	61		2.71		8	5.6	s.								.0	.0
La Crosse [2]	714	11	48	29.24	29.95	−.01	75.6	+2.8	97	27	86	56	30	65	34	66	62	67	1.46	−2.1	8	4.5	s.	19	w.	27	13	12	6	4.4	.0	.0
Madison	974	70	78	28.94	29.95	−.02	74.8	+2.7	97	6	84	56	16	66	26	65	60	64	1.64	−2.2	5	6.8	s.	27	ne.	6	8	15	8	5.3	.0	.0
Charles City	1,015	10	51	28.90	29.97	+.01	74.3	+2.0	98	6	86	53	1	63	31	66	61	68	1.66	−2.1	12	5.4	se.	19	s.	3	15	13	3	3.5	.0	.0
Davenport	606	66	161	29.32	29.97	.00	77.4	+2.1	98	12	87	60	16	68	26	68	63	66	3.86	+.5	5	8.2	sw.	34	nw.	5	11	10	10	5.1	.0	.0
Des Moines [2]	860	5	99	28.92	29.93	−.03	78.5	+3.1	105	12	90	60	1	68	31	68	64	68	4.11	+.6	7	8.3	se.	35	n.	3	11	17	3	4.2	.0	.0
Dubuque	699	60	79	29.22	29.95	−.02	76.2	+2.1	98	27	86	55	17	66	29	66	61	64	5.30	+1.4	9	5.1	s.	22	nw.	6	12	11	8	4.9	.0	.0
Keokuk	614	64	78	29.30	29.94	−.04	78.8	+1.9	99	7	88	58	16	69	25	70	66	68	2.37	−1.0	6	6.0	sw.	24	w.	4	10	13	8	5.2	.0	.0
Cairo	358	87	93	29.59	29.96	−.04	80.4	+.8	99	7	89	65	30	72	28	72	69	72	1.36	−1.7	7	6.4	n.	39	n.	15	6	19	6	5.4	.0	.0
Peoria [2]	609	11	45	29.26	29.96	−.02	76.2	+.8	97	13	86	58	30	66	28	68	65	74	4.80	+1.2	7	4.4	s.	16	ne.	5	20	5	6	3.8	.0	.0
Springfield, Ill. [2]	636	5	191	29.31	29.95	−.03	79.0	+2.5	101	13	89	60	16	69	27	69	65	69	1.07	−1.8	3	9.4	s.	29	s.	28	7	12	12	5.8	.0	.0
St. Louis [2]	568	179	303	29.37	29.96	−.03	80.6	+1.8	100	13	90	66	30	71	28	71	66	66	2.07	−.9	7	9.8	sw.	41	nw.	25	12	15	4	4.0	.0	.0
Missouri Valley							**81.2**	**+5.2**										**62**	**2.14**	**−1.6**										**3.8**		
Columbia, Mo. [2]	784	6	66	29.12	29.93	−.05	80.8	+3.9	102	17	92	59	30	70	31	72	67	68	2.33	−1.2	5	7.3	s.	26	se.	16	10	16	5	4.4	.0	.0
Kansas City [1]	750	32	45	29.12	29.90	−.07	84.7	+6.6	105	15	96	65	30	74	33	71	65	57	1.18	−3.0	7	8.1	sw.	40	sw.	18	13	14	4	4.1	.0	.0
St. Joseph [2]	967	11	49	29.06	29.91		82.7	+5.3	104	16	94	63	1	71	30	72	69	72	.96	−2.8	3	7.5	se.	21	nw.	25	18	10	3	3.6	.0	.0
Springfield, Mo. [2]	1,324	5	78	28.58	29.96	−.02	80.6	+3.8	100	15	92	60	30	70	29	71	68	75	2.83	−1.4	6	7.6	s.	27	n.	28	17	10	4	3.2	.0	.0
Topeka	987	65	87	28.87	29.89		85.8	+8.0	109	12	99	63	30	73	36	70	62	52	1.26	−3.0	5	9.1	s.	34	w.	18	16	12	3	3.5	.0	.0
Lincoln [2]	1,189	11	81	28.66	29.88	−.07	81.9	+5.4	111	12	94	62	29	70	34	68	61	58	2.81	−1.0	11	8.6	se.	39	nw.	4	14	12	5	4.2	.0	.0
Omaha [1]	982	31	44	28.88	29.90	−.05	80.6	+3.9	110	12	93	59	29	68	33	70	65	65	4.05	+.5	12	9.4	se.	42	nw.	4	12	14	5	4.5	.0	.0
Valentine	2,598	47	54	27.26	29.90	−.03	77.5	+3.8	108	11	92	56	28	63	43	64	56	54	2.22	−.8	9	9.0	e.	41	nw.	16	20	8	3	3.2	.0	.0
Sioux City	1,138	64	106	28.72	29.89	−.06	79.2	+4.9	111	11	91	57	22	67	41	68	63	63	2.14	−1.4	11	8.4	s.	36	se.	24	13	15	3	4.2	.0	.0
Huron [1]	1,289	27	41	28.55	29.89	−.05	77.7	+5.9	106	11	92	55	1	64	41	65	58	58	1.60	−1.6	11	11.9	se.	36	se.	20	17	13	1	3.0	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Northern Slope							**72.2**	**+4.5**										**48**	**0.82**	**−0.7**										**3.9**		
Havre	2,507	11	67	27.31	29.89	−.02	73.0	+4.7	103	28	88	50	18	58	41	57	47	48	.21	−1.7	4	8.5	sw.	41	sw.	10	17	11	3	3.4	0.0	0.0
Helena	4,124	85	111	25.83	29.93	.00	70.2	+4.5	95	9	84	46	20	57	39	54	42	42	.44	−.7	6	8.2	sw.	30	w.	13	14	10	7	4.2	.0	.0
Missoula [2]	3,263	80	91				71.0	+3.4	103	27	87	43	17	55	46	55	44	49	.49	−.5	2	6.9	e.	31	nw.	31	17	8	6	3.8	.0	.0
Kalispell	2,973	48	56	26.94	29.93	.00	67.3	+3.2	96	28	82	42	17	52	42	53	45	55	.38	−.7	6	6.5	w.	26	w.	13	15	12	4	3.7	.0	.0
Miles City [2]	2,371	48	55	27.20	29.87	−.05	77.1	+4.2	104	10	91	54	22	64	38	61	51	48	1.01	−.5	9	6.3	s.	31	w.	16	17	8	6	3.6	.0	.0
Rapid City [2]	3,250	50	58	26.65	29.88	−.05	77.2	+6.2	105	20	91	56	21	64	43	60	48	43	1.78	−.6	7	7.6	w.	29	n.	20	18	12	1	3.2	.0	.0
Cheyenne [1]	6,144	5	39	24.06	29.92	.00	71.8	+5.1	100	11	88	47	23	55	44	53	40	43	.70	−1.4	5	9.3	nw.	31	nw.	30	14	12	5	4.4	.0	.0
Lander	5,352	60	68	24.72	29.89	−.03	71.4	+4.0	100	10	88	48	5	55	45	54	40	40	.35	−.3	2	5.5	w.	30	w.	1	15	10	6	4.3	.0	.0
Sheridan	3,790	10	47	26.11	29.93	.....	72.0	.....	104	10	89	43	21	55	51	58	50	56	2.43	+1.2	5	4.6	s.	26	se.	15	15	16	0	3.3	.0	.0
Yellowstone Park	6,235	12	46	24.00	30.04	+.12	63.6	+2.7	90	14	78	37	21	49	41	49	39	50	.86	−.4	10	7.7	sw.	30	sw.	4	14	9	8	4.5	.0	.0
North Platte [2]	2,821	11	51	27.08	29.88	−.05	79.6	+6.7	106	12	94	59	28	66	36	64	56	55	.35	−2.4	7	7.4	se.	28	sw.	4	14	11	6	4.7	.0	.0
Middle Slope							**81.8**	**+4.7**										**47**	**0.47**	**−2.3**										**3.4**		
Denver [2]	5,292	106	113	24.77	29.88	−.03	77.1	+4.9	102	20	90	59	1	64	34	56	41	37	.08	−1.6	1	8.0	s.	34	n.	27	10	16	5	4.4	.0	.0
Pueblo [2]	4,690	79	86	25.22	29.87	−.04	77.4	+3.2	102	20	93	54	1	62	43	58	48	46	.13	−1.8	5	7.5	e.	27	ne.	16	16	11	4	4.2	.0	.0
Concordia	1,392	50	58	28.46	29.88	−.07	84.0	+6.0	110	12	97	62	19	71	34	68	59	50	.34	−3.4	6	8.0	s.	27	sw.	24	18	9	4	3.5	.0	.0
Dodge City	2,509	10	86	27.36	29.88	−.05	83.2	+4.8	105	20	97	61	1	70	34	65	55	46	.93	−2.2	4	12.1	sw.	43	ne.	1	19	11	1	3.1	.0	.0
Wichita [2]	1,358	85	93	28.48	29.90	−.06	84.4	+5.0	104	21	96	64	24	73	33	69	63	..	.72	−2.7	7	10.5	s.	24	s.	16	20	7	4	2.7	.0	.0
Oklahoma City [2]	1,214	10	47	28.58	29.92	−.04	84.7	+4.1	107	21	96	66	30	73	34	70	64	56	.62	−2.2	5	8.8	s.	28	n.	22	22	7	2	2.2	.0	.0
Chadron, Nebr	3,439	4	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Southern Slope							**83.1**	**+1.9**										**54**	**1.88**	**−0.5**										**3.8**		
Abilene [2]	1,738	10	56	28.14	29.90	−.03	86.0	+3.2	105	8	98	66	11	74	33	69	61	53	.94	−1.2	4	10.0	s.	23	n.	21	20	7	4	3.4	.0	.0
Amarillo [2]	3,676	10	49	26.37	29.91	−.01	80.6	+3.8	100	21	93	63	1	68	30	64	56	..	.57	−2.3	8	8.7	s.	22	n.	8	15	16	0	3.5	.0	.0
Del Rio	960	63	71	28.90	29.86	−.04	86.8	+.5	108	9	97	70	12	77	30	71	65	53	.68	−1.7	3	11.3	se.	27	ne.	11	13	15	3	4.1	.0	.0
Roswell	3,566	75	85	26.38	29.90	+.02	78.9	.0	99	7	91	62	11	66	32	64	56	55	5.32	+3.1	10	7.7	s.	35	ne.	9	12	14	5	4.2	.0	.0
Southern Plateau							**79.8**	**+1.1**										**43**	**1.02**	**−0.5**										**3.6**		
El Paso [2]	3,778	82	101	26.05	29.84	.00	83.1	+2.0	103	1	95	66	4	71	30	63	55	49	.60	−1.4	9	8.6	e.	30	ne.	9	9	15	7	4.9	.0	.0
Albuquerque [1]	5,314	5	39	25.10	29.87	.....	76.2	−.5	97	20	92	54	5	61	40	58	48	48	2.33	+.9	7	8.0	se.	40	ne.	22	13	10	8	4.1	.0	.0
Santa Fe	7,013	38	53	23.39	29.95	+.07	69.4	+.4	88	7	82	53	27	57	32	53	42	46	2.19	−.2	11	6.0	e.	24	n.	22	10	9	12	5.5	.0	.0
Flagstaff	6,907	10	59	23.47	29.85	+.02	67.6	+2.6	93	13	84	41	6	51	42	.....	.....	.....	.90	−2.3	7	8.6	nw.	24	n.	24	9	15	7	.....	.0	.0
Phoenix [2]	1,107	39	51	28.66	29.76	−.02	92.4	+2.6	114	13	106	70	5	79	35	68	55	33	.71	−.4	2	6.5	w.	33	ne.	23	20	10	1	2.5	.0	.0
Yuma	141	9	54	29.63	29.77	+.01	91.8	+1.0	119	12	107	65	4	76	41	71	59	40	.11	−.1	3	5.9	sw.	30	nw.	11	28	3	0	.9	.0	.0
Independence	3,957	5	26	.....	.....	.....	78.0	−.1	98	22	92	55	31	64	37	.....	.....	.....	.29	+.2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.0	.0
Middle Plateau							**75.6**	**+2.7**										**34**	**0.26**	**−0.3**										**3.0**		
Reno [2]	4,52[illegible]	61	76	25.60	29.93	+.06	73.2	+3.1	100	27	90	46	6	57	42	53	41	47	.62	+.4	4	7.1	w.	30	w.	3	21	7	3	2.5	.0	.0
Tonopah	½,090	[illegible]	20	.....	.....	.....	74.6	.....	94	22	88	51	6	62	31	53	36	..	.69	.....	4	.....	se.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.62	29.91	+.01	74.4	+3.8	102	9	93	46	7	56	50	53	36	30	.09	−.1	4	6.9	sw.	28	s.	12	17	10	4	2.9	.0	.0
Modena	5,473	10	46	24.66	29.86	.00	72.1	+1.5	98	13	89	47	4	55	45	52	35	32	.16	−.9	3	10.7	sw.	39	sw.	10	18	5	8	3.4	.0	.0
Salt Lake City [1]	4,227	32	46	25.73	29.86	−.04	78.3	+2.6	103	9	91	56	7	65	36	57	42	36	.11	−.4	3	7.4	n.	34	ne.	27	19	6	6	3.2	.0	.0
Grand Junction	4,602	60	68	25.38	29.86	−.03	80.1	+2.4	104	12	95	59	7	66	39	56	37	27	.34	−.3	2	6.6	se.	29	s.	2	19	7	5	2.9	.0	.0
Northern Plateau							**73.6**	**+2.9**										**42**	**0.44**	**−0.1**										**2.9**		
Baker	3,471	36	54	26.55	29.97	+.02	69.0	+3.4	103	27	86	41	17	52	44	52	42	51	.59	.0	5	6.0	n.	18	n.	15	20	8	3	3.0	.0	.0
Boise [2]	2,739	79	87	27.15	29.89	−.04	75.9	+3.0	102	13	91	48	17	61	38	57	25	45	.15	−.1	2	5.6	nw.	26	ne.	27	21	5	5	2.9	.0	.0
Pocatello [1]	4,478	5	31	25.50	29.91	−.01	72.2	+1.4	102	9	89	46	22	56	48	54	40	39	.86	−.1	6	9.2	sw.	32	sw.	20	14	13	4	3.6	.0	.0
Spokane [2]	1,929	101	110	27.90	29.92	−.04	72.4	+3.4	105	27	86	48	8	58	39	55	42	43	.40	−.3	3	7.2	s.	24	sw.	15	19	10	2	2.7	.0	.0
Walla Walla	991	57	65	28.89	29.94	−.03	76.8	+2.8	109	27	90	53	17	64	39	58	42	34	.54	+.2	2	6.3	s.	24	nw.	10	19	5	7	3.2	.0	.0
Yakima	1,076	58	67	28.82	29.95	.....	75.0	+3.6	110	27	90	48	6	60	39	57	44	39	.11	−.2	1	7.3	nw.	20	nw.	28	24	3	4	2.1	.0	.0
North Pacific Coast Region							**65.0**	**+1.6**										**69**	**1.18**	**+0.5**										**4.2**		
North Head	211	8	56	29.86	30.08	.00	57.2	.0	66	7	61	50	25	53	11	55	54	90	1.13	+.2	12	15.0	n.	36	s.	3	8	10	13	6.1	.0	.0
Seattle [2]	125	90	321	30.02	30.06	+.02	65.9	+2.8	94	27	76	52	2	56	32	57	52	68	.64	.0	8	8.5	n.	36	sw.	13	16	5	10	4.1	.0	.0
Tacoma	263	172	201	29.86	30.06	.00	64.4	+1.6	94	27	74	50	7	55	29	.....	.....	.....	1.03	+.4	8	8.2	n.	27	sw.	13	17	9	5	3.6	.0	.0
Tatoosh Island	86	9	55	29.98	30.08	+.03	54.9	−.2	69	22	59	49	17	51	18	53	51	89	3.75	+2.2	11	9.3	sw.	27	s.	3	7	9	15	6.3	.0	.0
Medford [1]	1,329	29	58	28.58	29.96	.....	73.6	+1.9	108	26	90	47	20	57	49	58	47	48	.34	.0	3	.....	nw.	.....	.....	.....	22	5	4	2.5	.0	.0
Portland, Oreg. [2]	154	68	106	29.99	30.03	−.02	69.4	+2.7	98	26	80	52	7	58	31	59	53	62	.79	+.2	4	7.2	nw.	19	s.	13	18	6	7	3.9	.0	.0
Roseburg	510	45	76	29.47	30.01	−.02	69.6	+2.2	104	26	84	46	20	55	46	58	49	56	.59	+.3	4	5.1	n.	18	n.	31	20	5	6	3.0	.0	.0
Middle Pacific Coast Region							**68.6**	**+1.4**										**61**	**0.30**	**+0.2**										**3.4**		
Eureka	60	72	88	29.98	30.05	.00	56.6	+1.1	68	14	61	49	14	52	19	53	52	86	.23	+.1	3	6.8	n.	21	n.	15	8	9	14	6.3	.0	.0
Redding [1]	722	20	34	.....	.....	.....	83.2	+1.4	109	24	97	60	5	70	32	60	42	28	.96	+.9	2	8.0	nw.	26	nw.	3	24	5	2	1.7	.0	.0
Sacramento [2]	66	92	115	29.86	29.88	.00	75.8	+2.6	106	21	93	53	2	59	43	59	48	48	T	.0	0	8.3	s.	19	sw.	3	27	3	1	1.0	.0	.0
San Francisco	155	112	132	29.79	29.96	+.01	59.0	+.5	80	20	64	50	2	54	27	55	52	83	T	.0	0	11.4	w.	34	w.	15	12	12	7	4.6	.0	.0
South Pacific Coast Region							**73.5**	**+0.3**										**60**	**T**	**0.0**										**2.6**		
Fresno [1]	327	97	105	29.57	29.86	+.03	81.8	−.3	109	22	99	55	2	64	42	61	45	34	.00	.0	0	7.2	nw.	22	nw.	5	25	5	1	1.4	.0	.0
Los Angeles	338	159	191	29.57	29.93	+.03	70.6	+.4	89	12	80	59	6	62	25	62	58	70	T	.0	0	5.5	sw.	14	sw.	11	20	9	2	2.8	.0	.0
San Diego [2]	87	62	70	29.91	29.94	+.02	68.1	+.9	77	25	73	58	16	63	12	63	60	76	T	.0	0	6.9	w.	18	w.	10	17	12	2	3.5	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.96	30.05	.....	79.8	−.3	88	7	84	71	20	76	13	.....	.....	.....	3.31	−2.6	18	13.0	e.	36	e.	5	8	22	1	4.8	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, July 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Panama Canal	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Balboa Heights	118	6	92	[1]29.83		+.01	81.2	+.9	91	2	88	70	23	75	20			[2]85	5.06	−2.2	19	6.0	nw.	35	s.	23	0	17	14	7.5	0.0	0.0
Cristobal	36	6	97	[1]29.85		+.01	82.2	+1.8	89	25	86	75	20	78	13	77	75	[2]85	6.67	−8.9	19	9.2	n.	21	nw.	27	0	9	22	8.0	.0	.0
Alaska																																
Fairbanks	454	11	87	[4]29.33	[4]29.83		60.4	+.4	86	20	72	41	27	49	35	53	48	70	2.18	+.2	11	5.4	s.	24	w.	13	6	7	18	6.8	.0	.0
Juneau	80	96	116	[4]29.91	[4]29.99		56.4	−.7	77	18	62	46	26	51	27	52	48	77	8.44	+3.3	22	7.3	se.	22	se.	19	3	5	23	8.4	.0	.0
Nome	22	5	57																													
Hawaiian Islands																																
Honolulu	38	86	100	30.00	30.04		76.9	−.8	83	17	81	69	19	72	11	69	66	72	1.32	+.1	15	9.9	e.	22	ne.	15	8	18	5	5.2	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city-office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to mean of 24 hours.

NOTE.—Except as indicated by notes, [1] and [2], data contained in table 2 are city office records.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, July 1939*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.+2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				51.2	−4.0	59.6	42.9	70	38	4.34	+0.69	
Sydney, Cape Breton Island	48	29.83	29.95	+0.01	65.4	+1.5	75.0	55.7	91	47	3.57	+.13	
Halifax, Nova Scotia	88	29.71	29.96	.00	66.7	+1.9	74.8	58.6	87	52	3.91	+.07	
Yarmouth, Nova Scotia	65	29.85	29.96	.00	62.2	+1.5	71.0	53.4	81	48	3.10	−.36	
Charlottetown, Prince Edward Island	38	29.85	29.93	+.01	67.5	+2.4	75.9	59.1	87	52	2.65	−.39	
Chatham, New Brunswick	28	29.79	29.89	−.01	68.0	+1.6	79.0	57.1	94	46	2.82	−1.21	
Father Point, Quebec	20	29.86	29.88	+.02	59.8	+2.0	67.6	52.1	80	47	4.53	+1.35	
Quebec, Quebec	296												
Doucet, Quebec	1,236	28.59	29.92	−.01	59.4	+.9	72.6	46.3	90	34	5.63	+.60	
Montreal, Quebec	187	29.73	29.93	+.02	70.6	+1.1	78.4	62.9	90	54	4.71	+1.01	
Ottawa, Ontario	236	29.57	29.94	+.02	67.2	−1.6	75.8	58.6	92	46	5.32	+1.93	
Kingston, Ontario	285	29.65	29.96	+.02	69.3	+.9	80.9	57.7	91	48	2.79	−.16	
Toronto, Ontario	379	29.55	29.96	.00	71.8	+2.5	81.6	61.9	93	50	1.72	−1.16	
Cochrane, Ontario	930				64.1	+1.5	76.3	51.9	88	38	4.14	+.72	
White River, Ontario	1,244	28.64	29.95	+.03	62.1	+1.5	76.9	47.3	89	33	1.99	−1.12	
London, Ontario	808	29.13	29.98		68.8	−.4	80.5	57.1	90	40	2.30	−.76	
Southampton, Ontario	656				66.4	+.9	75.9	56.9	90	45	3.11	+.73	
Parry Sound, Ontario	688	29.29	29.96	+.02	68.4	+1.4	78.3	58.5	90	49	1.92	−.75	
Port Arthur, Ontario	644	29.25	29.96	+.03	61.2	−1.7	73.5	48.9	85	39	2.24	−1.27	
Winnipeg, Manitoba	760	29.10	29.91	−.02	70.4	+3.7	83.9	57.0	100	35	1.42	−1.65	
Minnedosa, Manitoba	1,600	28.12	29.89	−.01	68.0	+4.3	82.0	54.0	93	40	2.56	+.07	
Le Pas, Manitoba	860	28.87	29.82	−.07	65.2	+.9	77.8	52.8	89	40	1.78	−.54	
Qu'Appelle, Saskatchewan	2,115	27.65	29.89	−.03	68.0	+4.0	82.6	53.4	96	43	1.21	−1.46	
Moose Jaw, Saskatchewan	1,759				70.4	+4.8	84.6	56.1	98	48			
Swift Current, Saskatchewan	2,392	27.16	29.93	+.03	66.0	+.3	78.6	53.3	93	45	2.17	−.19	
Medicine Hat, Alberta	2,365	27.43	29.86	−.02	70.2	+1.0	85.3	55.1	104	45	.73	−1.07	
Calgary, Alberta	3,540	26.32	29.93	+.01	62.2	+1.5	76.7	47.8	94	39	.67	−1.93	
Banff, Alberta	4,521				56.4	−1.3	69.9	42.9	89	33	.46	−1.71	
Prince Albert, Saskatchewan	1,450	28.33	29.86	−.05	66.9	+3.9	79.0	54.8	96	47	1.34	−.93	
Battleford, Saskatchewan	1,592	28.16	29.87	−.04	67.3	+3.9	81.6	53.0	100	44	1.27	−.93	
Edmonton, Alberta	2,150	27.62	29.87	−.01	63.3	+1.9	76.1	50.5	89	41	1.52	−1.76	
Kamloops, British Columbia	1,262												
Victoria, British Columbia	230	29.81	30.06	+.02	59.6	−.3	67.6	51.6	81	47	1.18	+.77	
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170	29.89	30.07	−.01	56.2	+.2	62.3	50.2	73	46	3.57	−1.30	
St. George's, Bermuda	158		30.13	+.01	78.5	+.1	84.2	72.8	88	69	6.45	+2.89	0.0
LATE REPORTS FOR JUNE 1939													
Quebec, Quebec	296	29.62	29.94	+0.04	61.7	+0.4	69.8	53.6	82	43	7.17	+3.17	
Banff, Alberta	4,521				47.6	−4.2	58.1	37.2	82	25	3.85	+.98	

TABLE 4.—*Severe local storms, July 1939*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Hooker and Bakersfield, Tex., vicinity of.	1	9 p. m.	[1] 3		$10,000	Hail, rain, and wind.	Principal damage to wheat estimated at $10,000; many young fowl drowned; path 10 miles long.
Little Rock, Ark.	2	11:45 a. m.			1,000	Thunderstorm	Property damaged.
Daniels and Sheridan Counties, Mont.	2	1:15–6 p. m.	[1] 2		100,000	Heavy wind and hail.	Loss to crops; path 100 miles long.
Hill and Blaine Counties, Mont.	2	7:30 p. m.	[1] 6			Heavy hail	Much loss to crops, amount not estimated; path 30 miles long.
Keokuk County, Iowa	3	11 a. m.			8,000	Wind and rain	Loss to crops, $6,000; property damaged; livestock killed.
Rockwell City, Iowa	3	5:30 p. m.		1	500	Electrical	Property damaged.
Polk, Jasper, and Marion Counties, Iowa.	3	7:30 p. m.			20,000	Wind, rain, and hail.	5 persons injured; telephone and electric service interrupted; property damaged.
Sioux, Crawford, Shelby, Pottawattamie, and Audubon Counties, Iowa.	3	P. m.			100,000	Rain, hail, and flood.	6 persons injured; property damaged.
Manilla, Iowa, vicinity of.	3		880		25,000	Heavy hail	Loss to crops; path 4 miles long.
Sheboygan County, Wis., northwestern portion.	4	1–2 p. m.	[1] 6		1,000	Hail	Many windows broken; roofs and automobile tops damaged; poultry killed; path 10 miles long.
Dubuque County, Iowa	4	1–3 p. m.			50,000	Thunderstorm and hail.	Loss to crops, $25,000; many trees down; property damaged.
Pierre and Blunt, S. Dak.	4	2:35–3:30 p. m.	440–5,280		1,500	Wind	Property damaged; small crop loss.
Fallon County, Mont.	4	P. m.	[1] 3		20,000	Wind and hail	Loss in small grains; path 14 miles long.
Easton, Ill.	4				2,000	Electrical	Property damaged.
Ada, Minn., and vicinity	5	3 p. m.	[1] 2–3		90,000	Thundersquall and hail.	2 barns wrecked; number of outbuildings damaged; many basements flooded; growing crops damaged considerably by washing and flooding. Loss to crops from hail, $75,000; damage from wind and flooding, $15,000. Length of path about 25 miles from east to west.
Bedford and Halifax Counties, Va.	5	4 p. m.			5,500	Thunderstorm and hail.	$2,500 loss in tobacco in Halifax County and $3,000 to roads and bridges in Bedford County.
Lac qui Parle and Lyon Counties, Minn.	5	6:30–8 p. m.	100	0	51,000	Tornado and hail.	Farm residences and outbuildings demolished; much livestock and poultry perished; poles and wires down; trees uprooted; farm machinery damaged; loss to growing crops, $6,000; property damage, $45,000; path about 45 miles long.
Cass Lake, Minn., and vicinity.	5	7–7:15 p. m.	[1] 7		25,000	Thunderstorm and hail.	Property damaged; crop loss about 10 percent; path 20 miles long from west to east.
Armenia and Baton Rouge, S. C., and vicinities.	5	11 p. m.			10,000	do	Severe damage to 24 farms; loss to crops, $6,000; property damage, $4,000.
Kentucky, eastern portion.[2]	5	P. m.		46		Cloudburst and flood.	Water rose 10 to 15 feet in less than 30 minutes. Bridges, homes, stores, and school buildings swept away.
Humboldt to Hartford, S. Dak., and vicinities.	5–6	11:45 – midnight.	[1] 1		40,000	Heavy hail	Loss to crops.
Wagener, S. C.	6	A. m.			3,500	Electrical	Barn with grain and feed burned; 7 hogs and 3 cows killed.
Twin Falls and Gooding Counties, Idaho.	6	2:30–4 p. m.	[1] 2½			Rain and hail	Corn, beans, beets, and grain beaten to the ground in small areas; irrigation ditches flooded; path 5 miles long.
Woodbury and Plymouth Counties, Iowa.	6	6:30 p. m.	[1] 3		125,000	Wind and hail	Property damage, $25,000; loss to crops, $100,000.
Martin County, Ind.	6		[1] 4		4,000	Wind	Property damage, $1,000; loss to crops, $3,000.
Bancroft, Wis., vicinity of.	6		[1] 4–5		700	Squall	Silo and several small buildings blown over.
Lesterville, S. Dak., vicinity of.	6–7	11 p. m.–1 a. m.	[1] 10		40,000	Wind	Property damage, $15,000; loss to crops, $25,000.
Lyon County, Iowa	7	12:30–3 a. m.	[1] 2		17,000	do	Property damage, $15,000; loss in corn crop, $1,500 and in livestock, $500.
Douglas County, S. Dak.	7	1–2 a. m.			25,000	do	Property damage, $15,000; loss to crops, $10,000.
Tripp, S. Dak., vicinity of.	7	1:15 a. m.	110		2,500	do	Property damaged; small crop loss.
Hurley, S. Dak., vicinity of.	7	1:30–2:30 a. m.	[1] 3		20,000	do	Property damage; crop loss small.
Bridgeport, Nebr.	7	5:30–6:30 p. m.	[1] 2		50,000	Hail	$2,000 property damage; $48,000 crop loss.
Salem, Ill.	7				1,000	Wind	Loss in fruit.
Detroit, Mich., and vicinity.	8	5 a. m.			1,000	Wind, electrical	Property damaged.
Wadena County, Minn.	8	11:30 p. m.	1,320			Thunderstorm and hail.	Some fields of grain totally destroyed; path 18 miles long.
Sullivan County, Ind.	8	P. m.			10,000	Wind and hail	Several houses unroofed; trees down; crops damaged.
New Burnside, Ill.	8				2,500	Electrical	Barn and contents burned.
Palestine, Ill.	8				1,500	Hail, electrical	Loss to crops from hail, $500; electrical damage to property, $1,000.
Traverse City, Mich.	8				50,000	Hail	Loss in cherry and apple crops; windows broken.
Knoxville, Tenn., and vicinity.	8–9	11:03 p. m.–12:20 a. m.			35,000	2 storms, electrical and rain.	House demolished as it plunged down a steep hillside with an avalanche of loosened earth after the storm; damage to telephone, telegraph and power circuits; streets flooded; loss to crops; damage from rainfall, $27,000 and from lightning, $8,000.
Halifax, Henry, and Roanoke Counties, Va.	9	4:30 p. m.			25,000	Hail	Chief loss in tobacco.
Knoxville, Tenn.	9–10				17,500	Electrical and rain.	Damage to power lines and telephone circuits; small crop loss.
Rockland County, N. Y., central portion.	10	5:15–6 p. m.	2,640		90,000	Wind and hail	Hail loss to fruits and vegetables, $40,000; many apple trees uprootted and hundreds of bushels of apples blown off causing $50,000 loss; path 15 miles long.
Norfolk, Va.	10	5:37–9:30 p. m.			20,000	Thunderstorm and hail.	Sewers inadequate; water accumulated to a depth of from 2 feet in the residential area to over 3 feet in the downtown district. No damage from hail.
Frederick County, Va.	11	2 p. m.			20,000	Hail	Loss to apples and other crops.
Galveston, Tex.	11	2:30 p. m.	100		1,000	Thundersquall	Property damaged.
Hill County, Mont.	14	6–7 p. m.	[1] 4			Heavy rain and hail.	Severe damage to grain crops; many fowls killed; path 15 miles long.
Cairo, Ill.	15	A. m.			1,000	Thundersquall	Considerable damage to trees, power and electric lines; smokestack blown over.
Yellowstone County, Mont.	16	4–7 p. m.	[1] 5		35,000	Hail	Damage mostly on range land; path 30 miles long.
Plymouth County, Iowa	16	5:30 p. m.			25,000	do	Loss chiefly to crops.
Rosebud and Treasure Counties, Mont.	16	7–9:30 p. m.	[1] 3		10,000	Hail and wind	Loss to crops; path 20 miles long.
Florence, Lee, and Darlington Counties, S. C.	16	P. m.			7,000	Hail	Loss to crops.
Wichita County, Kans., southwestern portion.	17	3:30 p. m.	[1] 5		10,000	Heavy hail	Loss to crops; path 10 miles long.
Woodhull, Ill.	17				700	Wind	Property damage, $200; crop loss, $500.
Cedar Rapids, Anamosa and Monmouth, Iowa, and vicinities.	17				15,000	Heavy rain	Damage from flooding and erosion.
Shawnee and Jefferson Counties, Kans.	18	2 p. m.	33	0	2,500	Tornado	Property damage most severe on 1 farm; path 12 miles long.

[1] Miles instead of yards.
[2] From press reports.

TABLE 4.—*Severe local storms, July 1939*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Estancia to Corona, N. Mex.	18	2–5 p. m.	[1] 1		$25,000	Hail	Chief loss to crops; path 5 miles long.
Wibaux County, Mont.	18	3–5 p. m.			10,000	Heavy hail	Damage in strips across the country.
Pittsylvania County, Va., southeastern portion.	18	6:30 p. m.			4,000	Tornadic winds	Loss to crops, $2,000; to livestock, $2,000; buildings damaged.
Smith County, Va., western portion.	19	3 p. m.			1,000	Hail	Loss to crops.
Pipestone County, Minn., southern portion.	19	3–4 p. m.	[1] 6			Thundersquall and hail.	Hail loss to crops 100 percent in places; much damage from washing and flooding; farm buildings damaged.
Chester, S. C., vicinity of	19	5 p. m.			2,000	Hail	Loss to crops.
Dodge County, Nebr., western portion.	19	9:30–9:45 p.m.	[1] 3–5		50,000	do	Loss in corn, fruits and vegetables, $45,000; property damage, $5,000.
Newberry County, S. C.	19				1,000	do	Loss to crops.
Martin, S. Dak.	20	6 p. m.	50		18,000	Tornado	Buildings, household goods, and cars wrecked; no crop loss.
Newberry, Kinards, and Silverstreet, S. C.	20				1,050	Electrical	Barn and small building destroyed.
Hutchinson, Minn., vicinity of.	21	10 a. m.	[1] 1		500	Thunderstorm and hail.	Loss to growing crops; path 5 miles long.
Holdenville, Okla., vicinity of.	21	9 p. m.	[1] 2		510	Wind	Property damaged; path 5 miles long.
Greenville, S. C.,[2] and vicinity.	21	P. m.				Thundersquall	Trees and telephone poles blown down; corn lodged; loss to crops;
Friona, Tex., vicinity of	22	4:50 p. m.	50		500	Tornado	Damage small because of few improvements in path of storm;
Poteau, Okla., and vicinities.	22	6:50–8:15 p.m.	[1] 10	1	200,450	Wind and rain	Many buildings destroyed, some being in the principal business section; path 25 miles long.
Farmington to Fayetteville, Ark.	22	7:30 p. m.	880		2,500	Hail	Loss to crops; path 4 miles long.
Tontitown to Elm Springs, Ark.	22	8 p. m.	350		2,500	do	Chicken house wrecked and several hundred chickens killed; loss to crops, $2,000; property damage, $500; path 3¼ miles long.
Hennessey, Okla., vicinity of.	22	do	[1] 10		100,000	Hail and wind	Cotton and corn stripped by hail; windows shattered; car tops and roofs damaged. In the Covington-Garber oil fields nearly a score of steel derricks were wrecked and many buildings unroofed; path 20 miles long.
Lane, S. C., vicinity of	22	11 p. m.			2,500	Electrical	Barn and feed burned; implements damaged.
Phillipsburg, Kans., vicinity of.	23	5:10 p. m.	[1] 1		20,000	Heavy hail	In some places hailstones drifted 10 inches deep. An airplane, 3 miles east of Phillipsburg, badly damaged; path 4 miles long.
Graham County, Kans., northern portion.	23	9:30 p. m.	[1] 12		55,000	Wind and hail	Property damaged; path 23 miles long.
Rooks and Russell Counties, Kans.	23	11 p. m.	[1] 15		30,000	Wind	Many farm buildings demolished, others damaged; path 28 miles long.
Waterloo, Ill.	23				2,500	Electrical	Property damaged.
Lockport, N. Y., vicinity of	23		880		5,000	Hail	Loss in vegetable crops; path 1 mile long.
Montgomery County, Iowa	24	1 a. m.	[1] 2		15,000	do	Loss to crops; property damaged.
Inman, Nebr.	24	3 p. m.	[1] 5		15,000	Hail and wind	Wind damage, $1,000; loss chiefly to corn from hail, $14,000.
Des Moines, Iowa [2]	24	P. m.				Thunderstorm	Property damaged; trees blown down; electric service interrupted.
Leoti, Kans., vicinity of	24	do		0		Tornado	Large barn damaged; bull killed; path narrow and short.
Albion, Mich.,[2] vicinity of	24	do			1,500	Electrical	Barn filled with hay burned.
Braymer, Mo.	25	4:30 a. m.		0	2,900	Tornado	1 person injured; property damage, $2,500; crop loss, $500.
Irvin's Ranch, N. Mex.	25	12:20–1:30p.m.	2,640		1,550	Heavy hail	Loss to crops.
Farmington, Ark.	26	2:45 p. m.			1,500	Straight-line wind	Property damaged: path short.
Hamburg, Ill.	26				5,000	Heavy hail	Loss to crops.
Tracy, Minn., and vicinity.	27	2:55–4 p. m.	[1] 15		2,000	Wind and rain	Farm buildings unroofed; windmills damaged; loss in corn crop; basements flooded; path 25 miles long.
Hartsville, S. C.	27	4:30 p. m.	67		1,500	do	Trees and hangar at airport blown down; roofs and chimneys damaged; grandstand unroofed.
Anna, Ill.	27				5,000	Hail	Loss in peaches and apples.
Villa Ridge, Ill.	27					Thunderstorm and hail.	Considerable loss to peaches and apples, to raspberry bushes, and to corn and peas.
Plymouth County, Iowa	27		[1] 3		10,000	Hail	Loss to crops; path 8 miles long.
Woodruff, S. C., vicinity of	27				650	Thunderstorm	Property damage, $500; loss in peaches, $150.
Indianapolis, Ind., and vicinity.	28	10:54 a. m.–4:08 p. m.				Thunderstorm and hail.	Considerable damage to power and telephone lines; streets and basement flooded by heavy rain.
Goodlett, Tex.	28	1:30 p. m.	880	0	1,000	Tornado	Principal damage to buildings.
Niagara County, N. Y.	28	4 p. m.	[1] 1		12,000	Wind and hail	Crop loss from hail, $10,000; property damaged by wind, $2,000; path 2 to 3 miles long.
Hanover and Chesterfield Counties, Va.	29	5:30 p. m.			9,500	Thunderstorm	Buildings damaged by lightning.
Hardin, Ill.	29				7,000	Heavy hail	Loss in crops.
Kingsbury and Lake Counties, S. Dak.	30	5–5:25 p. m.	[1] 3		20,000	do	Crop loss, $19,000; property damage, $1,000.

[1] Miles instead of yards.
[2] From press reports.

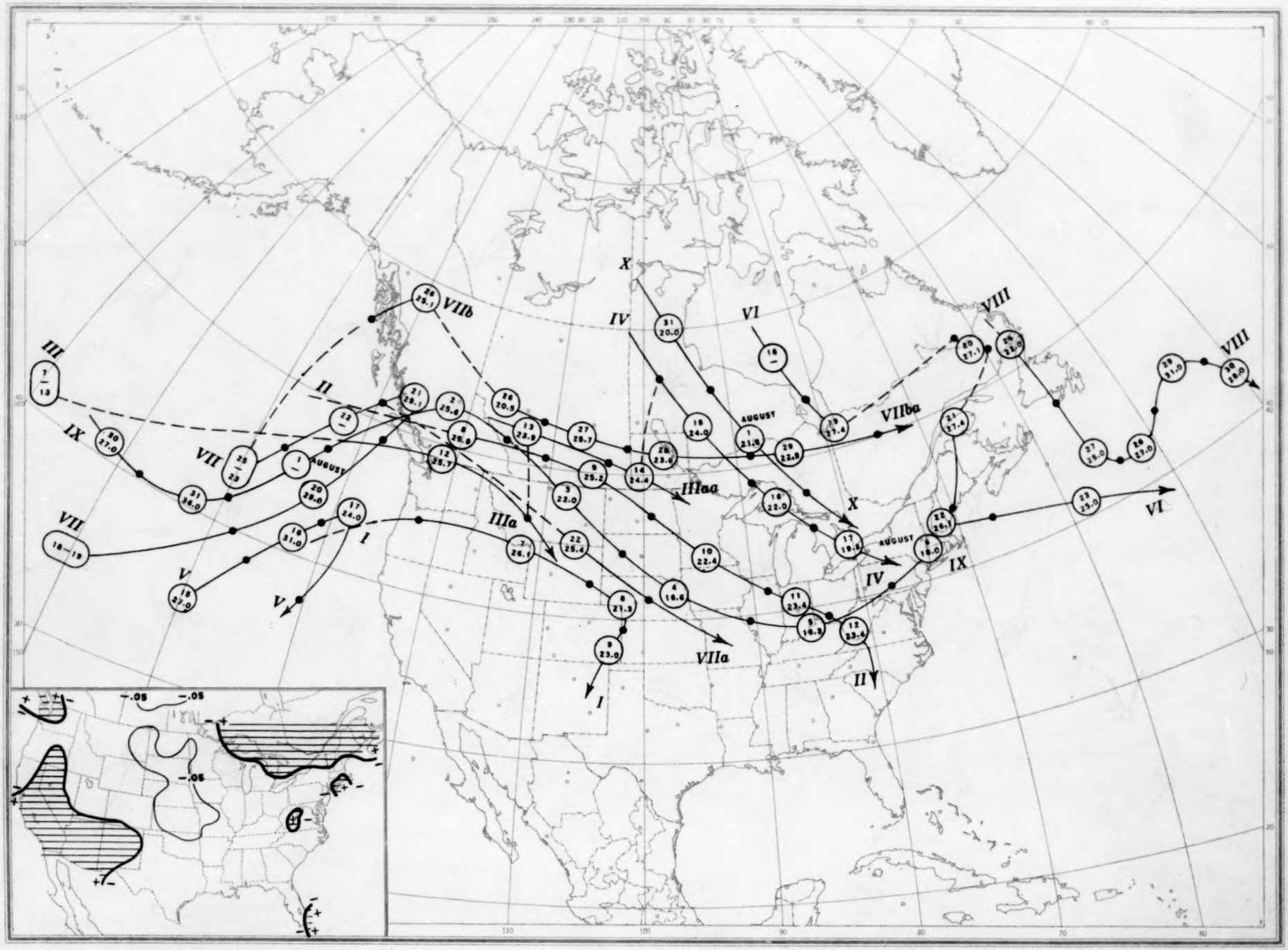
ERRATA

On page 123, table 4, Severe Local Storms, Review for April 1939, the storm published on the 5th, Marietta, Ohio, and vicinity, and the one on the 12th, Lucas, Fulton, and Williams Counties, Ohio, occurred in March 1939, instead of April 1939, and should have been published in the Review for March 1939 instead of the one in which they appeared.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, July 1939

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, July 1939

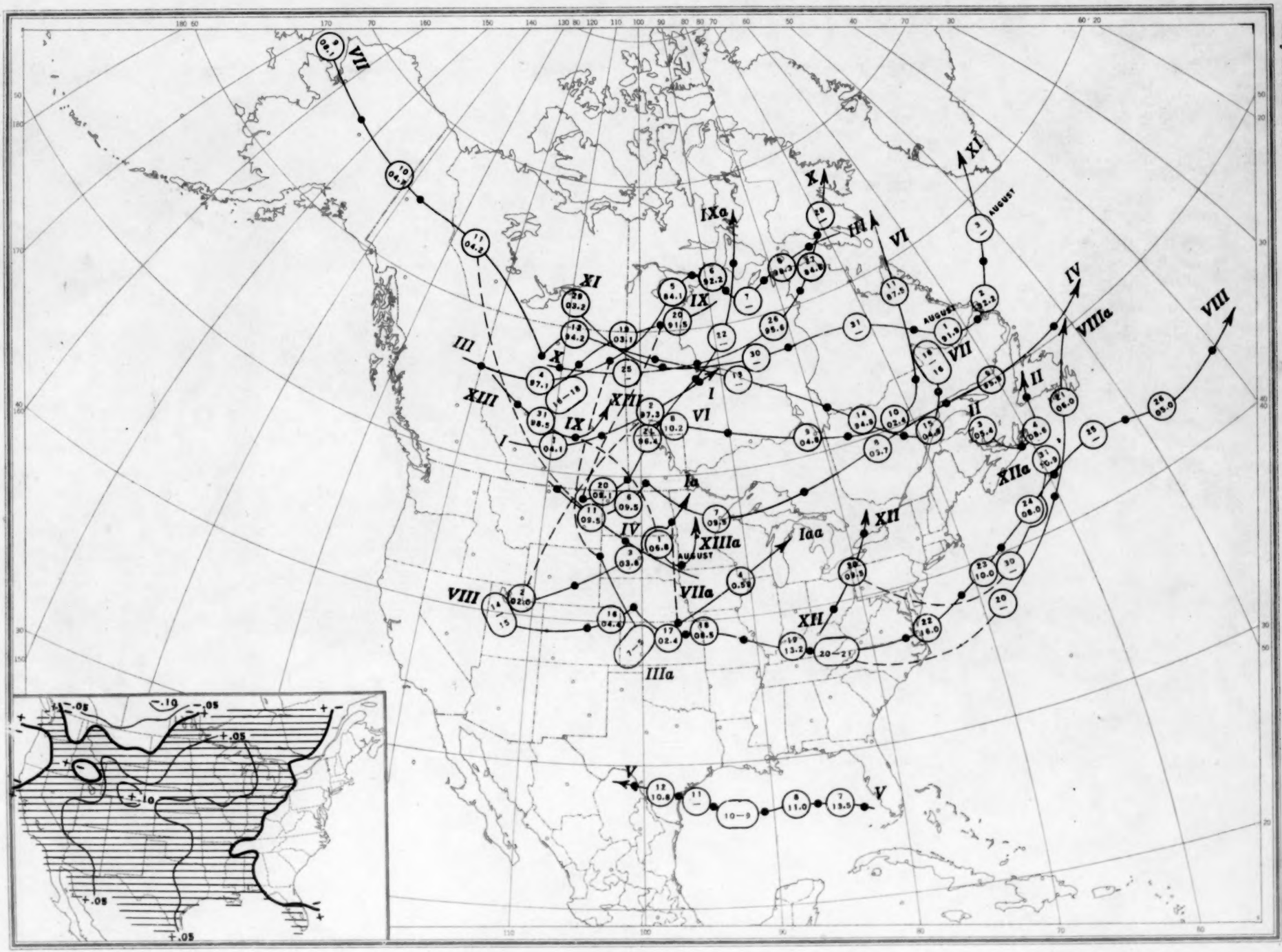
Chart II. Tracks of Centers of Anticyclones, July 1939. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, July 1939. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, July 1939. (Inset) **Change in Mean Pressure from Preceding Month**



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, July 1939

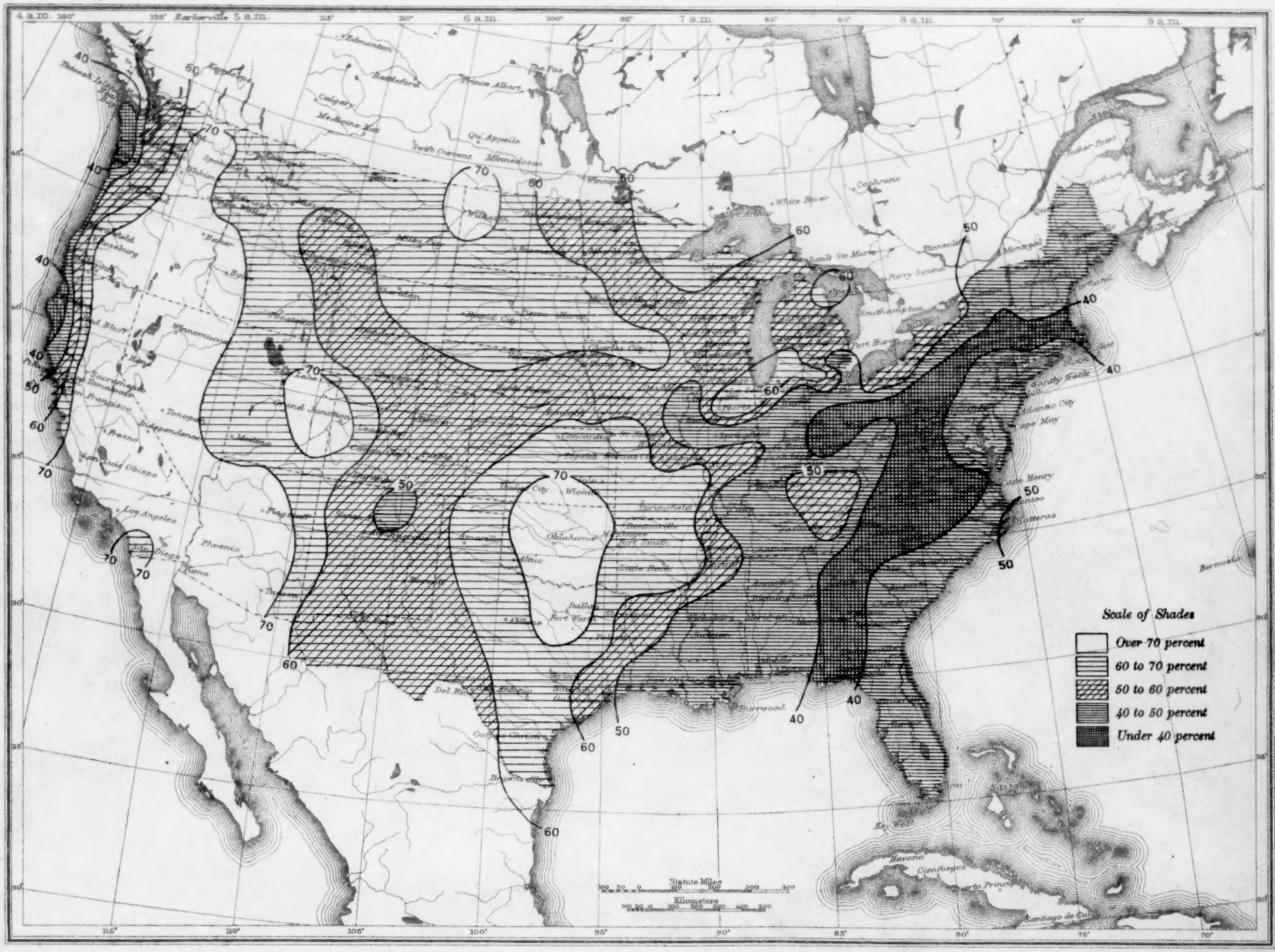


Chart V. Total Precipitation, Inches, July 1939. (Inset) Departure of Precipitation from Normal

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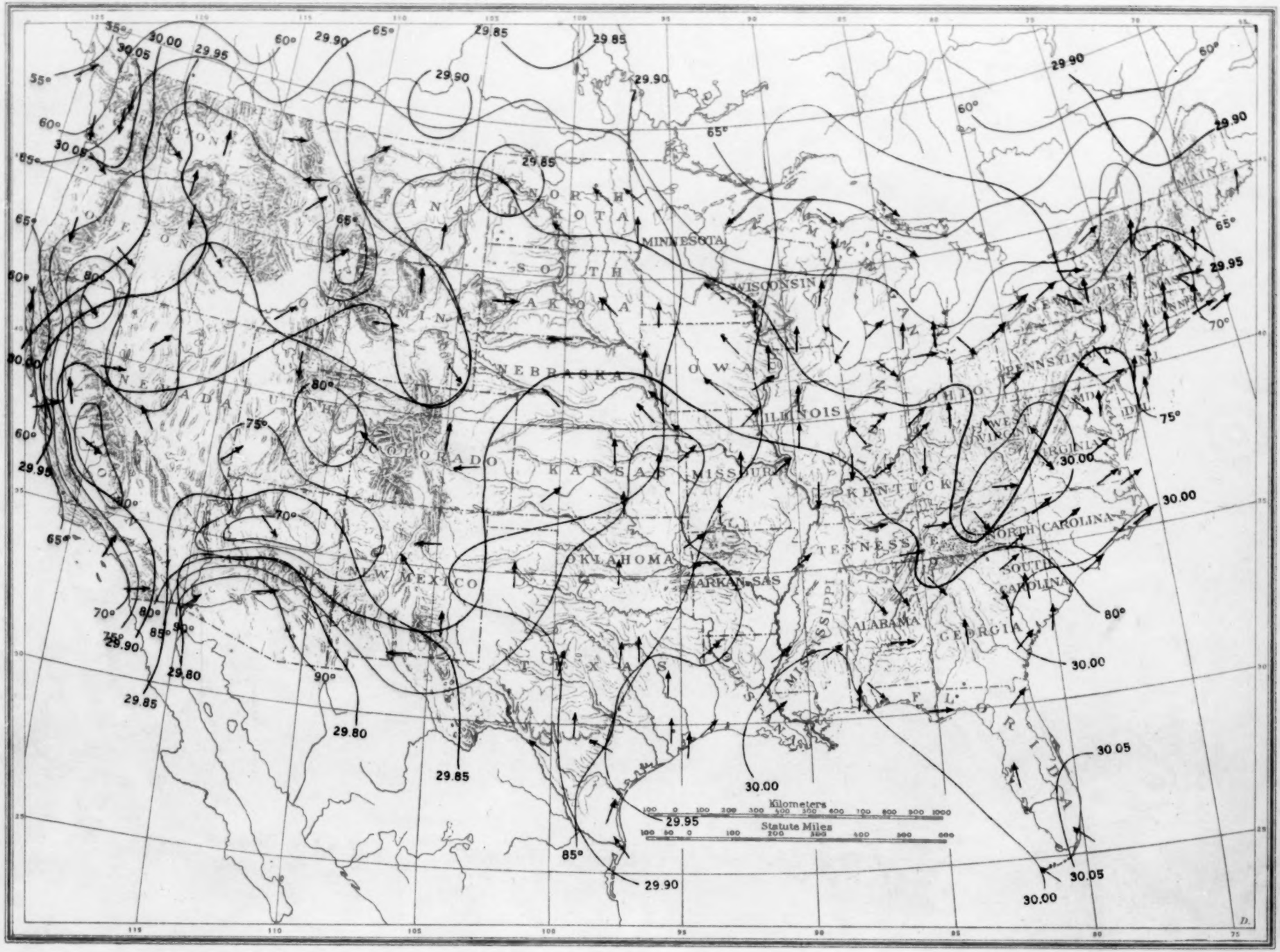
Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, July 1939